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CCD PHOTOMETRY OF ASTEROIDS 651 ANTIKLEIA, 738 ALAGASTA, AND 2151 HADWIGER USING A REMOTE COMMERCIAL TELESCOPE

Pedro V. Sada
Eder D. Canizales
Edgar M. Armada
Departamento de Física y Matemáticas
Universidad de Monterrey
Av. I. Morones Prieto 4500 Pte.
Garza García, N. L., 66238
MÉXICO

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CCD photometry of asteroids 651 Antikleia, 738 Alagasta, and 2151 Hadwiger obtained remotely at Tenagra Observatories during March, April and May 2004 is reported. Our lightcurve period and amplitude results: 651 Antikleia, 20.287 ± 0.004 hr, 0.40 ± 0.05 mag; 738 Alagasta, 17.83 ± 0.04 hr, 0.20 ± 0.03 mag; 2151 Hadwiger, 5.872 ± 0.002 hr, 0.35 ± 0.02 mag. The three asteroids show nearly symmetrical lightcurves, although a complete lightcurve for Antikleia was not obtained. Three other asteroids (1926 Demiddelaer, 2375 Radek and 4293 Masumi) were also observed on seven nights, but no satisfactory lightcurves could be obtained.

The observations of 651 Antikleia, 738 Alagasta and 2151 Hadwiger reported here were made with the Tenagra II telescope at Tenagra Observatories (MPC 926). The instruments used to gather the data were a computerized 0.81m (32-inch) f/7 Ritchey-Chrétien telescope with a SITe-based 1024x1024x24 μm electronic imager yielding ~0.87 arc-seconds per pixel for a field of view of ~15’x15’ (Schwartz, 2003). The chip temperature was set at –45º C and the images were 2x2 binned for file transfer economy. Tenagra Observatories offers commercial telescope time with two telescopes in southern Arizona. These are fully automated instruments. An observer only needs to send instructions on which objects to observe, and the imaging requests from several users are sorted and executed throughout the night. The data is stored for immediate FTP retrieval, including calibration frames. This convenient setup saves time, travel and lodging expenses and is ideal for individuals or universities with small research departments.

The targets were selected from a list of asteroid photometry opportunities published by Brian Warner on his Collaborative Asteroid Lightcurve Link (CALL) website (Warner, 2004). Selection criteria included: proximity of the asteroids to each other and to a nearby suitable star calibration field to save on telescope slewing time, asteroid declination and closeness of opposition date to dates of observation for maximum nightly coverage, appropriate asteroid magnitude to acquire enough counts for a S/N of at least 100 with 1-minute V-filtered exposures, and a high reported asteroid absolute magnitude (H-value) to target the smallest asteroid size possible.

Usable data were collected on 2004 March 16-17, 28-30 and April 14 & 16 for 651 Antikleia; and May 7 & 11-13 for 738 Alagasta and 2151 Hadwiger. All dates are UT. In total, 174 images were obtained and processed for Antikleia, 113 for Alagasta and 105 for Hadwiger, using a standard Johnson V photometric filter and 1-minute exposure times. Of these, 159 (91%) were used in the final analysis for Antikleia, 111 (98%) for Alagasta and 105 (100%) for Hadwiger. The rest were discarded because of asteroid proximity to stars. Standard bias, dark current and flat field corrections were applied. Five (in a few cases only three) stars were used in each image as magnitude comparisons for the asteroid. A nearby star field, identified from the 'LONEOS Photometric Calibration Star List' (Skiff, 2003), was observed each night for magnitude calibration. Stars with known magnitudes were used to determine the magnitudes of the asteroid comparison stars.

Times were corrected for light travel time from the asteroid to the Earth and were taken to be at the mid-times of the image exposures. Relative magnitudes from night to night were uncertain as different comparison star sets were used. This was dealt with by using additive constants to bring all the data into the best agreement possible. However, these arbitrary magnitude shifts were small (≤0.05 magnitudes). Additional magnitude shifts were also used to compensate for the intrinsic magnitude variation of the asteroids due to their change of distance with respect to the Earth, and to phase angle variations (5.3º-13.4º for 651 Antikleia, 7.9º-10.0º for 738 Alagasta, and 11.1º-13.3º for 2151 Hadwiger).

The best-fit rotational periods for the asteroids were obtained by computing the power spectrum of the time series of data (Scargle, 1982; Horne and Baliunas, 1986). The resulting synodic rotational period for 651 Antikleia from the data presented here is 20.287 ± 0.004 hours. The amplitude of the lightcurve is 0.40 ± 0.05 magnitudes (Figure 1). For 738 Alagasta the resulting synodic rotational period was 17.83 ± 0.04 hours with an amplitude of 0.20 ± 0.03 magnitudes (Figure 2). For 2151 Hadwiger the resulting synodic rotational period was 5.872 ± 0.002 hours with an amplitude of 0.35 ± 0.02 magnitudes (Figure 3). The asteroids exhibited two similar maxima and minima per rotation. The time scale is given in rotational phase with the zero corresponding to the epoch, in Julian Day, indicated in each figure. The magnitude scale is also referenced to this same epoch.

This is probably the first reported rotational period for 651 Antikleia and 738 Alagasta since they are not listed in A. Harris and B. Warner's 'Minor Planet Lightcurve Parameters' list (Harris and Warner, 2005). For Antikleia the rotation period and coverage were such that we were unable to obtain a complete lightcurve, although we are confident about the result since we had a one-month baseline of observations. The uncertainty in the derived period for Alagasta is comparatively larger since we had little overlap in the lightcurve with only four nights of observations spread over a week.

Alvarez-Candal et al. (2004) report a rotation period for 2151 Hadwiger of 2.29 ± 0.01 hours and an amplitude of 0.38 magnitudes from a single night of observations in April 2000. Although our amplitudes are consistent for this asteroid, we cannot explain the discrepancy in the derived rotational periods. More specifically, we do not see the bimodal nature of the lightcurve Alvarez-Candal et al. show in their 2.17 hours of coverage. Also, phasing our data with their period did not yield a reasonable lightcurve. However, we are confident about our result since we observed the asteroid for over 18 hours on 4 nights (covering 3 full rotations) and used five comparison stars to obtain asteroid magnitudes.

Other Asteroids Observed

As part of the same program we observed three other asteroids over seven nights (nearly coincident with the observations of 651 Antikleia) during March and April of 2004. These asteroids were 1926 Demiddelaer, 2375 Radek, and 4293 Masumi. These asteroids exhibited small brightness variations (<0.10 magnitudes) during each observing session, and we were unable to derive an unambiguous rotation period through their power spectrum. We then attempted to obtain a reasonable lightcurve by sequentially adopting rotation periods using time increments of 0.001 hours and phasing the data. These were visually inspected in order to find the best fit possible. Small nightly magnitude shifts (≤0.05 mag.) to the data were also attempted. No clear and satisfactory solutions were apparent. Our inability to find rotation periods for these asteroids may be related to the fact that they may possess low brightness amplitudes, long rotation periods, complex lightcurve shapes, or a combination of these. It was also apparent that longer exposure times (greater S/N) would have been helpful in clearly delineating the observed low amplitude brightness variations.

Acknowledgments

This research was partially supported by a grant from the American Astronomical Society. We would also like to thank R. Hernández and other donors for contributing funds for these observations.

References

Alvarez-Candal, A., Duffard, R., Angeli, C. A., Lazzaro, D. and Fernández, S. (2004). "Rotational Lightcurves of Asteroids belonging to Families". Icarus **172** pp. 388-401.

Harris, A. W. and Warner, B. D. (2005). "Minor Planet Lightcurve Parameters". Posted on the WWW: http://cfa-www.harvard.edu/iau/lists/LightcurveDat.html (2005 February 5 update).

Horne, J. H. and Baliunas, S. L. (1986). "A Prescription for Period Analysis of Unevenly Sampled Times Series". Astrophysical Journal **302** pp. 757-763.

Scargle, J. D. (1982). "Studies in Astronomical Time Series Analysis. II - Statistical Aspects of Spectral Analysis of Unevenly Spaced Data". Astrophysical Journal **263** pp. 835-853.

Schwartz, M. (2003). "Tenagra Observatories, Ltd." Posted on the WWW: http://www.tenagraobservatories.com/

Skiff, B. (2003). "LONEOS Photometric Calibration Star List". Posted on the WWW: ftp://ftp.lowell.edu/pub/bas/starcats/loneos.phot (2003 July 15 update).

Warner, B. D. (2004). "Potential Lightcurve Targets 2004: January 1 – March 31" and "Potential Lightcurve Targets 2004: April 1 – June 30". Posted on the WWW: http://www.minorplanetobserver.com/astlc/default.htm

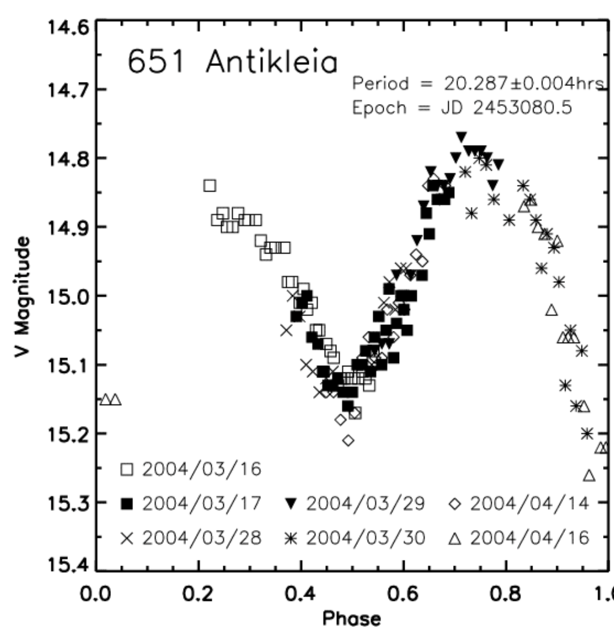


Figure 1: Composite lightcurve of asteroid 651 Antikleia derived from 159 observations and a 20.287-hour rotation period.

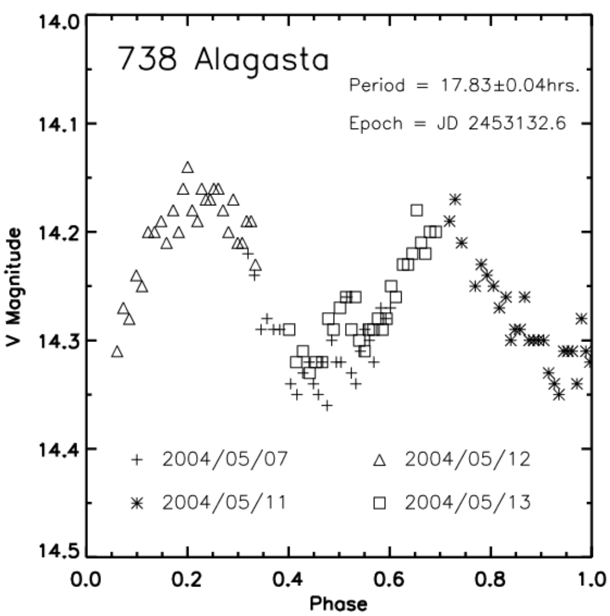


Figure 2: Composite lightcurve of asteroid 738 Alagasta derived from 111 observations and a 17.83-hour rotation period.

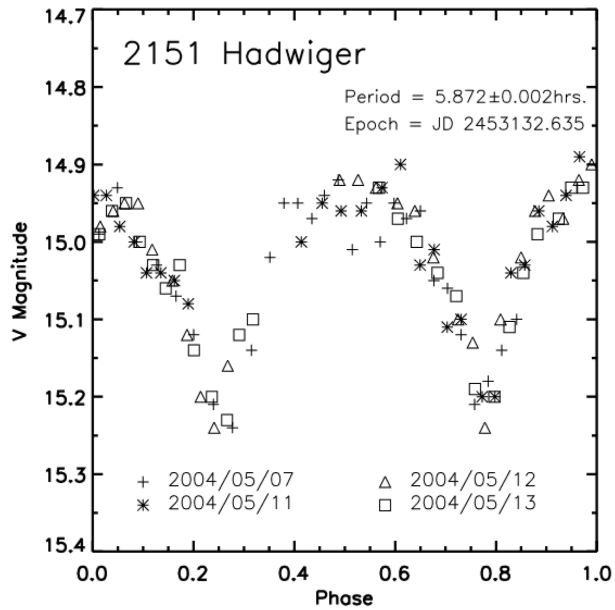


Figure 3: Composite lightcurve of asteroid 2151 Hadwiger derived from 105 observations and a 5.872-hour rotation period.

LIGHTCURVES AND PERIODS FOR ASTEROIDS 2103 LAVERNA AND 3445 PINSON

Daniel A. Klinglesmith
Quentin Jamieson
Etscorn Campus Observatory
New Mexico Tech
801 Leroy Place
Socorro, NM 87801

Frederick Pilcher
1101 West College Avenue
Illinois College
Jacksonville, IL 62650

(Received: 20 April)

Two asteroids were selected from the CALL list for asteroids with unknown periods. Data were obtained on 8 nights between March 30 and April 8, 2005. The period and amplitude results are: 2103 Laverna 9.249 ± 0.003 hr, 0.27 mag; 3445 Pinson 7.801 ± 0.002 hr, 0.37 mag. Laverna shows a bump on the second rising branch of its bimodal light curve while Pinson exhibits a more or less symmetrical bimodal lightcurve.

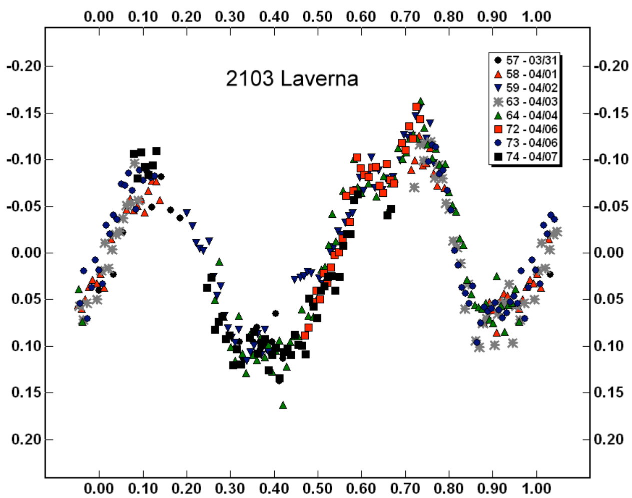
Here we report lightcurve observations of asteroids 2103 Laverna and 3445 Pinson made at the Frank T. Etscorn Campus observatory of New Mexico Tech using a Celestron C-14 and SBIG ST-8e CCD camera system mounted on a Bisque Paramount ME. We obtained all of our images through a Bessel-R filter. All of the exposures for 2103 Laverna were 120 seconds long. For 3445 Pinson we used 120 seconds for all but the last night when we switched to 180 seconds for a better signal-to-noise ratio. The telescope was controlled by Software Bisque's "*TheSky*" version 5 and the CCD was controlled by their "*CcdSoft*" version 5. The CCD was cooled to -15°C and automatic dark subtraction was used. On each night, a series of 11 dome flats was obtained using a tungsten-halogen lamp pointed at the opposite wall. These 11 images were median combined using IDL procedures as described in Jamieson and Klinglesmith (2004). These nightly master flats were combined at the end of the 10 night run to create a master flat that was used to flat field correct all the images for the final data analysis.

Both of these asteroids were moving slowly enough that a whole night's data (up to 6 hours) could be reduced in one session using the same comparison stars. Two methods were used to independently analyze the differential lightcurves. The first method used aperture photometry on the asteroid and all stars brighter than the asteroid. These stars' instrumental magnitudes were median combined and subtracted from the asteroid's instrumental magnitude to produce the differential lightcurve. The second method used MPO *Canopus* published by BDW Publishing, and used up to 5 comparison stars per night (session). The final periods were determined using the Fourier method from MPO Canopus. Standard light-time corrections were applied to the UT dates and times of the observations.

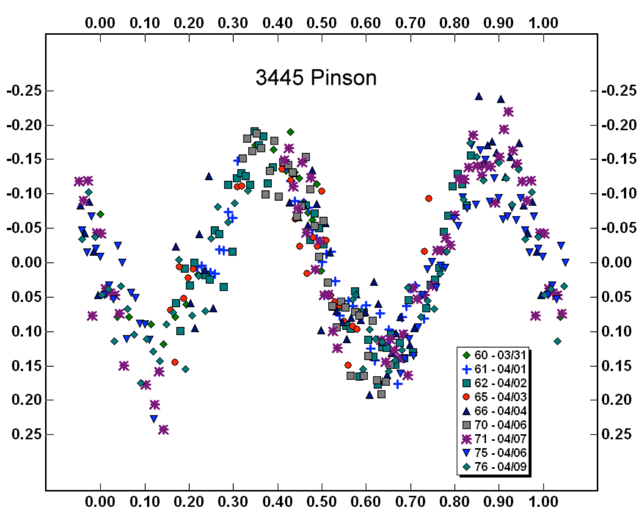
Our observing run lasted from UT March 30, 2005 through April 8, 2005. We were clouded out one night and winds were too high on another. The table below shows the UT dates of our observations, the number of images obtained for each asteroid for each night and the time interval (hr) of the observations. Assuming that our periods are correct, 2103 Laverna was observed for ~ 19 cycles and 3445 Pinson was observed for ~28 cycles.

UT date	2103 Laverna	3445 Pinson	time interval
04/01/2005	19	19	3.9hrs
04/02/2005	42	41	4.0
04/02/2005	57	56	4.9
04/03/2005	52	53	4.7
04/04/2005	80	79	6.5
04/04/2005	78	79	6.3
04/07/2005	71	70	5.8
04/09/2005	0	49	7.1

2103 Laverna. Laverna was discovered March 21, 1960 at the La Plata Observatory. We determined a bimodal period of 9.249 ± 0.003 hours with an amplitude of ~0.27 magnitudes in the Bessel-R filter. There is a sight dip of approximately 0.04 magnitude at phase 0.65 This dip helps rule out any other aliased period. The Julian date of zero phase is 2453460.636065, light-time corrected.



3445 Pinson. Pinson was discovered in 1983. This lightcurve was more challenging since several aliased periods presented themselves. We have chosen the bimodal period of 7.801 ± 0.002 hours with an amplitude of 0.37 magnitudes as the most probable period. This is based mainly on the fact that large amplitudes would be improbable for monomodal, trimodal or quadramodal lightcurves (Pravec 2005). The Julian date of zero phase is 2453460.638898, light-time corrected.



References

Jamieson, Q. and Klinglesmith, D.A. (2004). “Period Determination of asteroids 1508 Kemi and 5036 Tuttle”, *MPB* **31**, 38-39.

Pravec, P., Private communication, 2005

ROSE-HULMAN SPRING 2005 LIGHTCURVE RESULTS: 155 SCYLLA, 590 TOMYRIS, 1655 COMAS SOLÁ, 2058 ROKA, 6379 VRBA, AND (25934) 2001 DC74

Don Addleman, Brent Covele, Allison Duncan, Jama Johnson, Steve Kramb, Crystal LeCrone, Chris Reichert, Harry Starnes, Andrew Twarek, Elaine Kirkpatrick, and Richard Ditteon
Rose-Hulman Institute of Technology CM 171
5500 Wabash Avenue
Terre Haute, IN 47803
richard.p.ditteon@rose-hulman.edu

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CCD images recorded in March and April 2005 using the Tenagra Observatory 32-inch telescope yielded lightcurve periods and amplitudes for five asteroids: 155 Scylla 7.958 ± 0.002 h, 0.20 mag; 590 Tomyris 5.55 ± 0.05 h, 0.93 mag; 1655 Comas Solá 20.4 ± 0.1 h, 0.20 mag; 2058 Roka 10.09 ± 0.01 h, 0.50 mag; 6379 Vrba 5.11 ± 0.01 h, 0.36 mag; (25934) 2001 DC74 19.1 ± 0.05 h, 0.90 mag. Additionally, 12 targets listed herein were found to have too low a lightcurve amplitude after one night to continue following.

Nine undergraduate students from Rose-Hulman Institute of Technology (Addleman, Covele, Duncan, Johnson, Kramb, LeCrone, Reichert, Starnes, and Twarek) and two professors (Ditteon and Kirkpatrick) obtained images of asteroids during the spring of 2005. They used the commercial 32” Ritchey-Chretien telescope with a V-filter at the Tenagra Observatory in Arizona by submitting requests via FTP and downloading the resulting images via FTP. The telescope operates at f/7 with a CCD camera using a 1024x1024x24 μm SITe chip and the images were binned 2 by 2 (Schwartz, 2004). All exposures were taken for 60 seconds. They also used three 14” Celestron telescopes on Paramount mounts at the Oakley Observatory in Terre Haute, Indiana. The telescopes operate at f/7 with two Apogee AP7 and one Apogee AP8 cameras. The AP7s have 512x511x24 μm SITe chips, one of which uses a V-filter, and the AP8 has a 1024x1024x24 μm SITe chip. These exposures were 240 seconds for each image.

Asteroids for observation were selected by using *TheSky* software by Software Bisque. Only asteroids that were located between 20° and 30° in elevation at one hour after local sunset and with brightness between 14 and 16 mag were considered. The elevation requirement ensured that the asteroid would be high enough in the sky to avoid excessive airmass throughout the night. The asteroids were limited to the 14th magnitude because we pay for a minimum 60 seconds for each exposure, and brighter asteroids would saturate the CCD camera. Dimmer asteroids would require a longer exposure at a greater expense. The asteroids were then checked on a list of asteroid lightcurve parameters by Alan Harris (Harris, 2003). We tried to observe asteroids whose periods were previously unpublished or still had a relatively large certainties.

Observation requests for the asteroids and Landolt reference stars were submitted by Ditteon, Kirkpatrick and LeCrone using ASCII text files formatted for the TAO scheduling program (Schwartz, 2004). The resulting images were downloaded via FTP along with flat field, dark, and bias frames. Standard image processing was done using *MaxImDL*, published by Diffraction Limited. Photometric measurements and lightcurves were prepared using *MPO Canopus*, published by BDW Publishing.

A total of 18 asteroids were observed, but only six lightcurves were found. After looking at data from the first night, asteroids that showed either a very small variation in brightness or had too low a signal-to-noise ratio weren't observed further to save funding for more promising targets. The asteroids 153 Hilda, 241 Germania, 447 Valentine, 477 Italia, 619 Ueta, 630 Euphemia, 673 Edda, 931 Whittemora, 1343 Nicole, 2939 Coconins, 5237 Yoshikawa, 8882 Sakacamura produced data that either had little to no amplitude or were too noisy for a lightcurve to be distinguished. Our successful lightcurve results are detailed below.

<u>155 Scylla.</u> Asteroid 155 Scylla was discovered 8 November 1875 by J. Palisa at Pola. It was named for Scylla, the sea nymph who guarded the straight between Sicily and Italy with Charybdis. Scylla was the daughter of Phorcys and Ceto, and sister of the Gorgons, Sirens, and Graeae (Schmadel, 1999). A total of 78 images were obtained on 31 March and 1, 5, and 15 April 2005. The data reveal a lightcurve with a 7.958 ± 0.002 h period and 0.20 mag amplitude. All of the images of Scylla were taken at the Tenagra Observatory.

<u>590 Tomyris</u>. Asteroid 590 Tomyris was discovered 4 March 1906 by M. Wolf at Heidelberg. It was named for the queen of the Massagets in Scythia who sold and killed the Persian king Cyrus the Great in 529 B.C. (Schmadel, 1999). A total of 85 images were taken 15 and 16 April 2005. The data reveal a lightcurve with a 5.55 ± 0.05 h period and 0.93 mag amplitude. All of the images of Tomyris were taken at the Oakley Observatory. This result is in good agreement with 5.562 ± 0.002 hr found by Binzel (1987), where only 0.2 mag. amplitude was seen in Tomyris' 1983 apparition. The 2005 apparition may have been at a near-equatorial aspect.

<u>1655 Comas Solá</u>. Asteroid 1655 Comas Solá was discovered 28 November 1929 by J. Comas Solá at Barcelona. Fabra Observatory named the asteroid in memory of Jose Comas Solá (1868-1937). He was the first director of the Fabra Observatory and discovered the comet Comas Solá, a crater on Mars, and 11 other numbered minor planets (Schmadel, 1999). A total of 60 images were obtained on 31 March, 1 April, and 5 April 2005. The data reveal a lightcurve with a 20.4 ± 0.1 h period and 0.20 mag amplitude. Because the asteroid has such a long period (almost 24 hours), we did not collect data through its entire period and further observation is recommended. All of the images of Comas Solá were taken at the Tenagra Observatory.

<u>2058 Roka</u>. Asteroid 2058 Roka was discovered 22 January 1938 by G. Kulin at Budapest. It was named in memory of Gedeon Roka, a well-known popularizer of astronomy in Hungary for three decades (Schmadel, 1999). A total of 59 images were obtained on 31 March, and 1 April and 15 April 2005. The data reveal a lightcurve with a 10.09 ± 0.01 h period and a 0.50 mag amplitude. All of the images of Roka were taken at the Tenagra Observatory.

<u>6379 Vrba</u>. Asteroid 6379 Vrba was discovered 15 November 1987 by A. Mrkos at Klet (Schmadel, 1999). A total of 58 images were obtained on 31 March, and 1 and 5 April 2005. The data reveal a lightcurve with a 5.11 ± 0.01 h period and a 0.36 mag amplitude. All of the images of Vrba were taken at the Tenagra Observatory.

<u>(25934) 2001 DC74</u>. Asteroid (25934) 2001 DC74 was discovered 19 February 2001 by LINEAR at Socorro (MPC, 2005). A total of 58 images were obtained on 31 March, and 1 and 5 April 2005. The data reveal a lightcurve with a 19.1 ± 0.05 h period and a 0.90 mag amplitude. Because the asteroid has such a long period, we did not collect data through its entire period and further observation is recommended, particularly because its amplitude is so large. All of the images of 2001 DC74 were taken at the Tenagra Observatory.

All of our data are available upon request.

Acknowledgements

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References

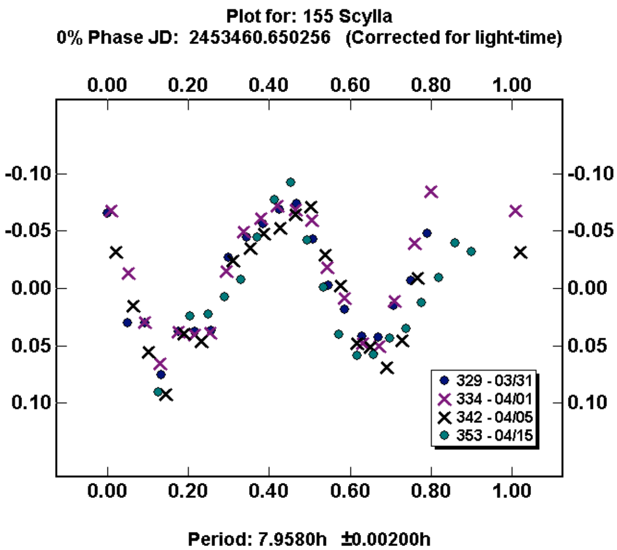
Binzel, R. P. (1987). A Photoelectric Lightcurve Survey of 130 Asteroids. *Icarus* **72**, 135.

Harris, A. W., Warner, B. D. (2004). Minor Planet Lightcurve Parameters. 2003 Dec. 15. http://cfa-www.harvard.edu/iau/lists/LightcurveDat.html, last referenced 29 April 2005.

Schwartz, M. (2004). "Tenagra Observatories, Ltd." http://www.tenagraobservatories.com/, last referenced 29 April 2005.

Schmadel, Lutz D. (1999). *Dictionary of Minor Planet Names*. Springer: Berlin, Germany. 4th Edition.

MPC (2005). Discovery Circumstances: Numbered Minor Planets (25001)-(30000). 2005 Apr. 8. http://cfa-www.harvard.edu/iau/lists/NumberedMPs25001.html, last referenced 4 May 2005.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342 - 04/05
353 - 04/15
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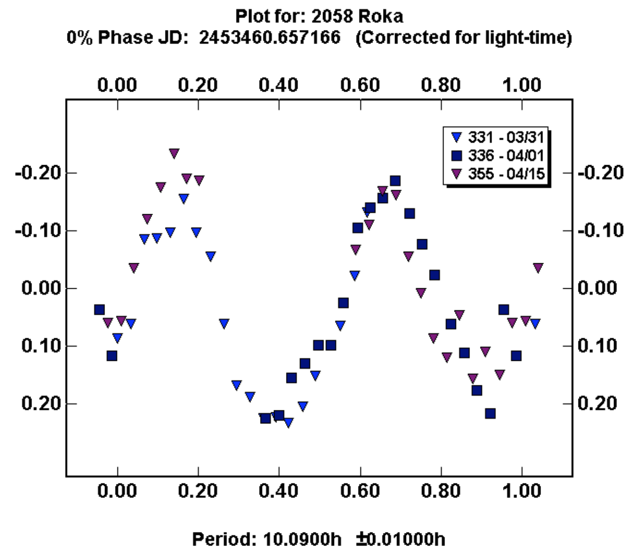
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336 - 04/01
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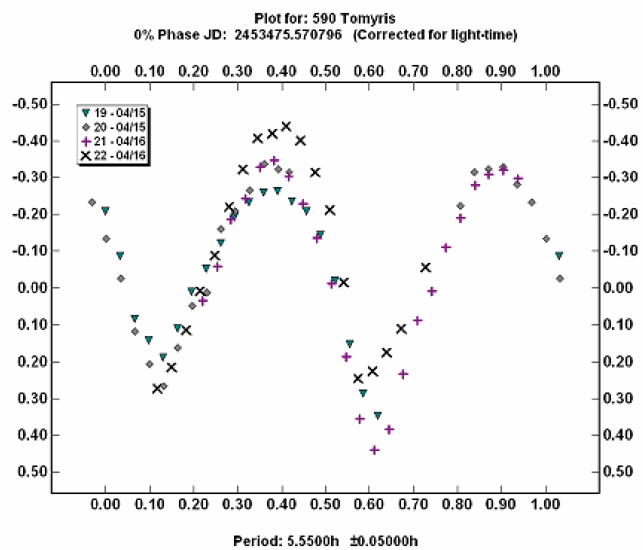
Period: 10.0900h ±0.01000h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19 - 04/15
20 - 04/15
21 - 04/16
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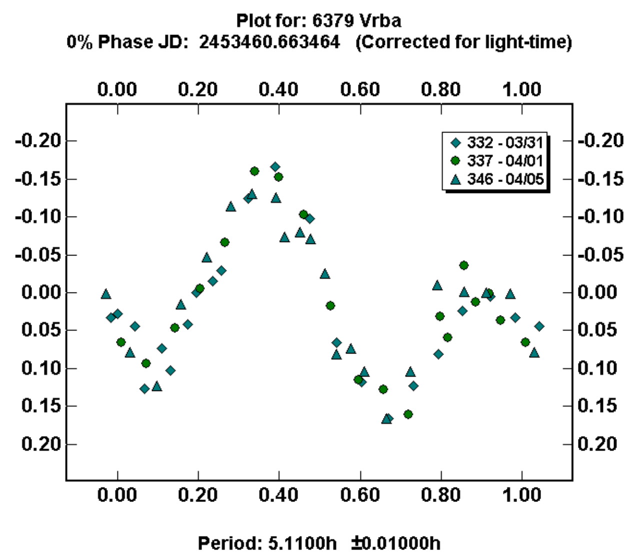
Period: 5.5500h ±0.05000h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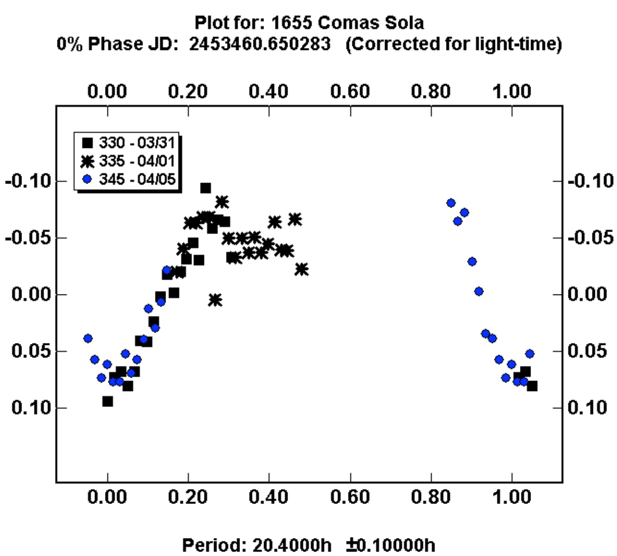
346 - 04/05
Period: 5.1100h ±0.01000h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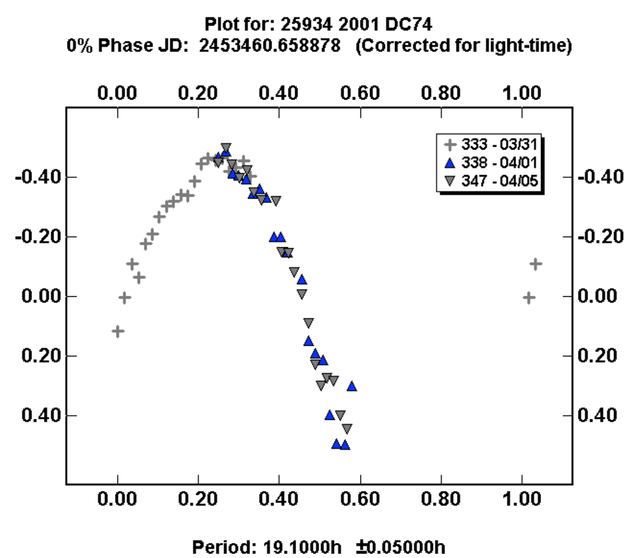
345 - 04/05
Period: 20.4000h ±0.10000h


Plot for: 25934 2001 DC74
0% Phase JD: 2453460.658878 (Corrected for light-time)
333 - 03/31
338 - 04/01
347 - 04/05
Period: 19.1000h ±0.05000h

ASTEROID PHOTOMETRY REPORTS FROM ALTIMIRA OBSERVATORY – WINTER 2004-2005

Robert K. Buchheim
Altimira Observatory (G76)
18 Altimira, Coto de Caza, CA 92679 USA
rbuchheim@earthlink.net

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Lightcurve periods and amplitudes have been measured for asteroids 1021 Flammario (P= 12.146 ± 0.001 hr, 0.36 mag) and 2105 Gudy (P= 15.788 ± 0.004 hr, 0.28 mag, and H=11.4).

Altimira Observatory is located in southern California. Details of the observatory and equipment are available at http://www.geocities.com/oca_bob. For the studies reported here, differential photometry was performed using CCD images taken through Johnson-Cousins B, V, and R filters.

<u>1021 Flammario</u>. Previous determinations of the rotation period of 1021 Flammario have been reported. Hainaut-Rouelle et al (1995) reported P= 8.097 hours, during the October, 1990 apparition. Their observations showed only one minimum and one maximum per night. Schober et al (1993) determined a light curve period P= 12.14 hours during the November, 1990 apparition, based on more-complete coverage of the rotation than was available to Hainaut-Rouelle (two minima are clearly distinguished in their light curve). Two nights (16 Jan 2005 UT and 30 Jan 2005 UT) were devoted to this object, with images made in B, V, and R bands on both nights. The Altimira data are consistent with the result of Schober: my lightcurve, wrapped to a period of P = 12.146 ± 0.001 hours, is shown in Figure 1. I also tried fits in the range 7.5 to 9 hours, bracketing the Hainaut-Rouelle period, but the subjective fit was poor, and the RMS error substantially larger than with P= 12.146 hrs. The SNR in all three filters was greater than 100:1, but no evidence of color variation with rotational angle was detected.

<u>2105 Gudy</u>. Four nights were devoted to this object over the range 11-24 December 2004, with images taken in B, V, and R bands on most nights. A lightcurve has been previously published by Warner (2001), and a report of brighter-than expected magnitude has been noted by Gressman (1981). The measured lightcurve matches a rotation period of P= 15.788 ± 0.004 hours, as shown in Figure 2. This is in excellent agreement with Warner's (2001) observations, which indicated a period of 15.8 hours. The measured color indices for this asteroid are: (B-V) = 1.05 ± 0.05 and (V-R) = 0.49 ± 0.05. The measured phase curve for 2105 Gudy is shown in Figure 3. Assuming a G value of 0.15, a slightly revised value of H=11.4 is suggested compared with the tabulated value of H=11.3 (PDS Small Bodies Node).

Acknowledgements

Photometric reductions were performed with Brian Warner's MPO Canopus/PhotoRed program. Ephemerides were calculated using Chris Marriott's SkyMap Pro program, using a database from the Minor Planet Center. Automated observatory control is accomplished with Software Bisque's suite (TheSky, Automadome, Orchestrate and CCDSoft).

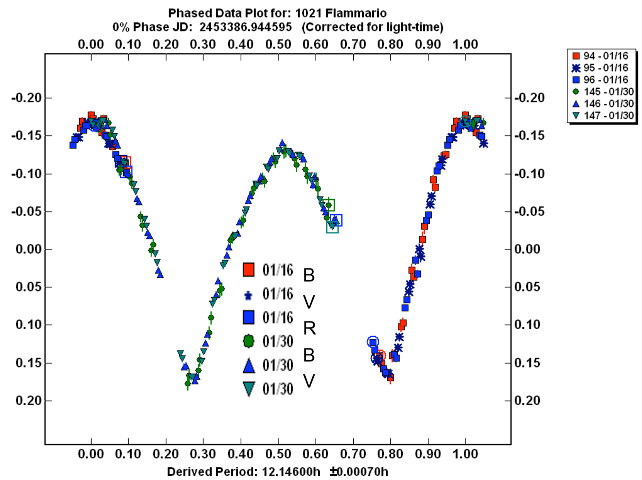


Figure 1: Lightcurve of 1021 Flammario, wrapped to P= 12.146 hrs.

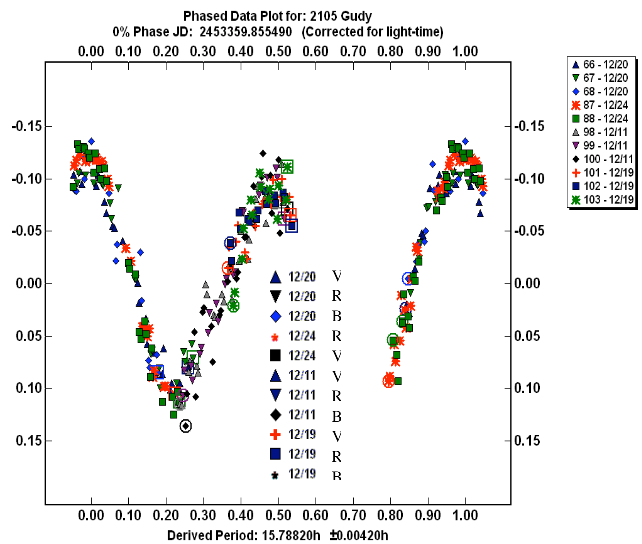


Figure 2: Lightcurve of 2105 Gudy, wrapped to P= 15.7882 hrs

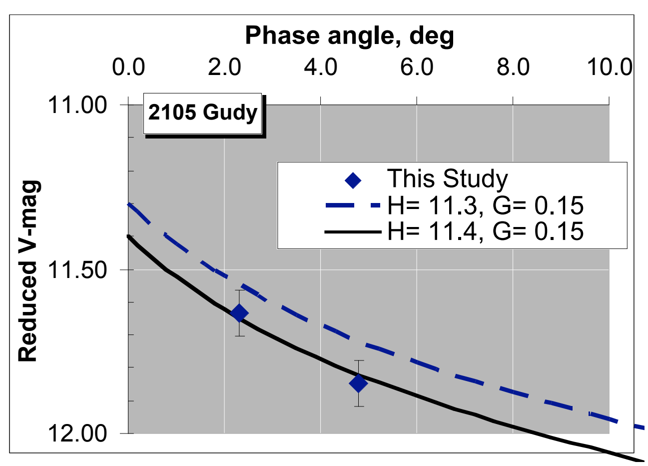


Figure 3: Phase curve fit for 2105 Gudy.

References

Gressman, M., in Letters, *Minor Planet Bulletin* **8**, 32-33.

Hainaut-Rouelle, M.C., et al. (1995) "Lightcurves of Selected Minor Planets". Astronomy and Astrophysics Supplement Series, **112**, 125-142

Schober, H. J., et al. (1993), "Physical Studies of Asteroids XXVI". Astronomy and Astrophysics Supplement Series, **101**, 499-505

Small Bodies Node of the NASA Planetary Data System, at http://pdssbn.astro.umd.edu/

Warner, B. (2001). "Asteroid Photometry at the Palmer Divide Observatory". *Minor Planet Bulletin* **28**, 30-32.

PHOTOMETRIC LIGHTCURVE OBSERVATIONS OF 125 LIBERATRIX, 218 BIANCA, 423 DIOTIMA, 702 ALAUDA, 1963 BEZOVEC, AND (5849) 1990 HF1

Michael Fauerbach
Thomas Bennett
Egan Observatory
Florida Gulf Coast University
10501 FGCU Blvd.
Fort Myers, FL 33965
mfauerba@fgcu.edu

(Received: 3 May)

Photometric lightcurve measurements from the Evelyn L. Egan Observatory for six main-belt asteroids are reported. The following synodic periods and amplitudes were determined: 125 Liberatrix 3.9683±0.0002h, 0.20 mag; 218 Bianca 6.337±0.001h, 0.09 mag; 423 Diotima 4.775±0.001h, 0.11 mag; 702 Alauda 8.348±0.001h, 0.05 mag; 1963 Bezovec 18.1600±0.0001h, 0.30 mag; (5849) 1990 HF1 8.733±0.001h, 0.40 mag.

The Evelyn L. Egan Observatory is located on the campus of Florida Gulf Coast University (FGCU) in Fort Myers, Florida. Details on the equipment and methods have been previous reported (Fauerbach 2005). Targets were selected from the "Potential Lightcurve Targets" list on the CALL website (Warner, 2002), with attention to those listed as potential shape-modeling targets. We also utilized the list of known lightcurve parameters maintained by Harris and Warner (Harris, 2003) to select targets that have a high uncertainty in their previously published periods.

125 Liberatrirx. Minor planet 125 Liberatrix is an M-type asteroid with a size of approximately 43 km. It was discovered by Prosper Henry on September 11, 1872. The asteroid was chosen for study, as it was a shape modeling target (Kaasalainen). Observations were obtained during 3 nights over December 12-27, 2004. Our derived rotational period is 3.9683±0.0002h with an amplitude of 0.20 mag., in good agreement with previous publications (see Harris 2003).

218 Bianca. Minor planet 218 Bianca is an S-type asteroid with a size of approximately 61 km. It was discovered by Johann Palisa on September 4, 1880 in Pola, Italy and was named after opera singer Bianca Bianchi. The asteroid was chosen for study, as it was a shape modeling target (Kaasalainen). Observations were obtained during 3 nights between December 12 and 27, 2004. Observations were also obtained during 4 nights between February 8 and April 6, 2005. Our derived rotational period is 6.337±0.001h with an amplitude of 0.09 mag, in good agreement with previous publications (see Harris, 2003).

423 Diotima. Diotima is a large (~209 km) C-type binary asteroid. It was discovered by Auguste Charlois on December 7, 1896 in Nice. The asteroid was chosen for study, as it was a shape modeling target (Kaasalainen). Observations were obtained on December 7 and 13, 2004. Our derived rotational period is 4.775±0.0001h with an amplitude of 0.11 mag, in good agreement with previous publications (see Harris, 2003).

702 Alauda. Alauda was discovered on July 16, 1910 by J. Helffrich in Heidelberg. The asteroid was chosen for study, as there was some ambiguity about the period. Observations were obtained during 6 nights between January 4, 2005 and February 12, 2005. We derived a synodic period of 8.348±0.001h with a small amplitude of 0.05 mag, in good agreement with the literature.

1963 Bezovec. This C-class asteroid was discovered on February 9, 1975 by L. Kohoutek. Lightcurve observations were obtained during 6 nights between January 6, 2005 and February 5, 2005. We derived a synodic period of 18.160±0.001h with an amplitude of 0.30 mag. No prior lightcurve data were available.

(5849) 1990 HF1. This asteroid was discovered on April 27, 1990 by E. F. Helin at Palomar. We observed it during 9 nights between January 4, 2005 and February 11, 2005. The derived synodic period that fits all the data best is 8.733±0.001h with an amplitude of 0.40 mag. No prior lightcurve data were available.

Acknowledgements. One of us (T.B.) acknowledges support from the Whitaker Center for Science, Technology and Mathematics Education at Florida Gulf Coast University.

References

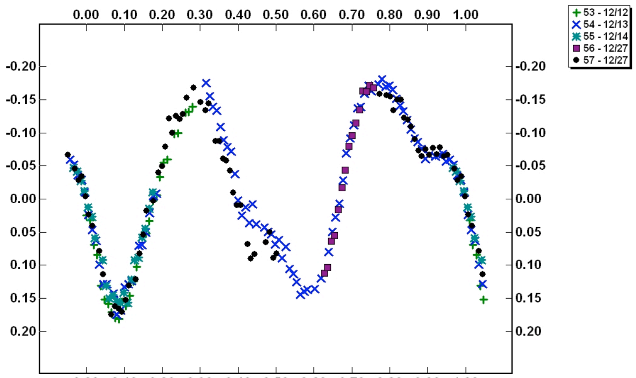
Fauerbach, M. and Bennett, T. (2005), "First Photometric Lightcurve measurements from the Evelyn L. Egan Observatory", *The Minor Planet Bulletin* **32-2**, 34-35

Warner, B. D. (2002), "Potential Lightcurve Targets", CALL website, http://www.MinorPlanetObserver.com/astlc/default.htm

Harris, A. W., and Warner, B. D. (2003). "Minor Planet Lightcurve Parameters", found on the Minor Planet Center website: http://cfa-www.harvard.edu/iau/lists/LightcurveDat.html

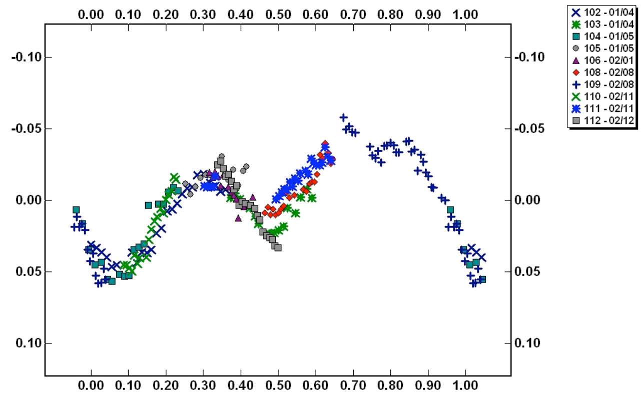
Kaasalainen, M. http://www.rni.helsinki.fi/~mjk/asteroids.html and references therein.

Phased Data Plot for: 125 Liberatrix
0% Phase JD: 2453352.487997 (Corrected for light-time)



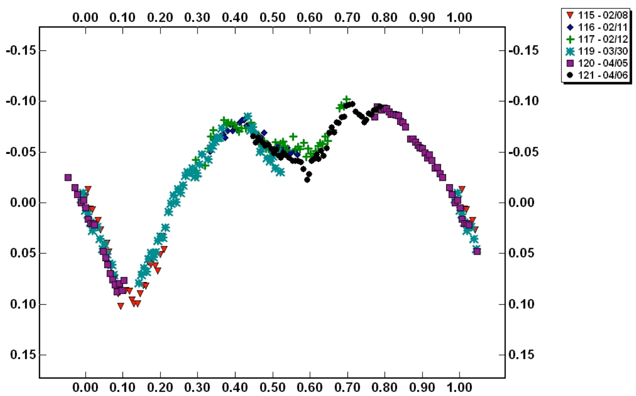
Derived Period: 3.9683h ±0.00020h
Amplitude: 0.28m

Phased Data Plot for: 702 Alauda
0% Phase JD: 2453374.749677 (Corrected for light-time)



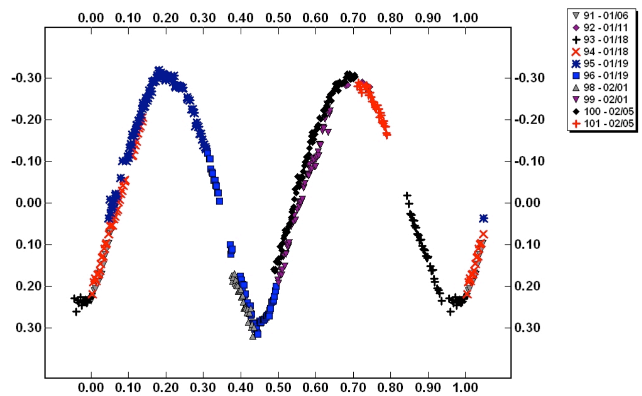
Derived Period: 8.3480h ±0.00100h
Amplitude: 0.05m

Phased Data Plot for: 218 Bianca
0% Phase JD: 2453409.902154 (Corrected for light-time)



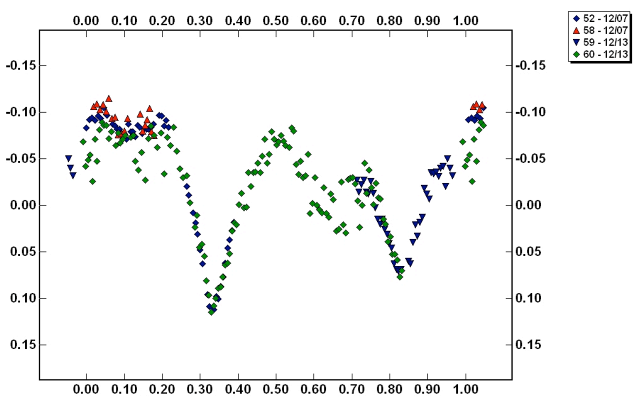
Derived Period: 6.3370h ±0.01000h
Amplitude: 0.09m

Phased Data Plot for: 1963 Bezovec
0% Phase JD: 2453376.728194 (Corrected for light-time)



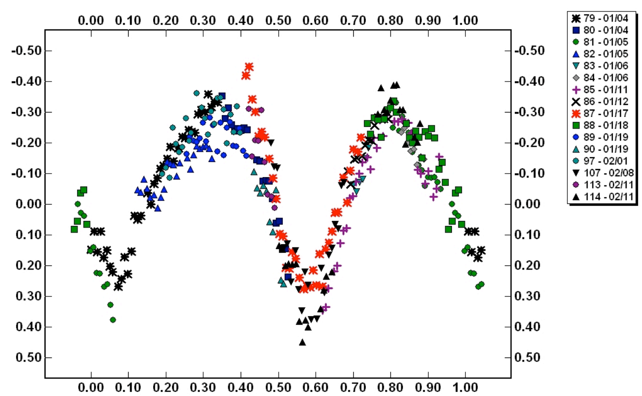
Derived Period: 18.1600h ±0.00010h
Amplitude: 0.55m

Phased Data Plot for: 423 Diotima
0% Phase JD: 2453346.587007 (Corrected for light-time)



Derived Period: 4.7750h ±0.00010h
Amplitude: 0.11m

Phased Data Plot for: 5849 1990 HF1
0% Phase JD: 2453374.508989 (Corrected for light-time)



Derived Period: 8.7330h ±0.00100h
Amplitude: 0.51m

ASTEROID LIGHTCURVE PHOTOMETRY FROM SANTANA OBSERVATORY – SPRING 2005

Robert D. Stephens
11355 Mount Johnson Court
Rancho Cucamonga, CA 91737 USA
rstephens@foxandstephens.com

(Received: 27 June)

Lightcurve period and amplitude results from Santana Observatory are reported for 2005 January-March. 816 Juliana (10.58 ± 0.02 hours and 0.52 mag.), 1140 Crimea (9.77 ± 0.01 hours and 0.28 mag.), 5215 Tsurui (3.81 ± 0.01 hours and 0.24 mag.)

Santana Observatory (MPC Code 646) is located in Rancho Cucamonga, California at an elevation of 400 meters and is operated by Robert D. Stephens. Details of the equipment used can be found in Stephens (2003) and at the author's web site (http://home.earthlink.net/~rdstephens/default.htm). All of the asteroids were selected from the "CALL" web site "List of Potential Lightcurve Targets" (Warner 2005). The images were measured using the software program MPO Canopus which uses differential aperture photometry to determine the values used for analysis. The period analysis was done within Canopus, which incorporates an algorithm based on the Fourier analysis program developed by Harris (1989).

The results are summarized in Table I and shown in the lightcurve figures. The data and lightcurves are presented without additional comment, because the circumstances for the asteroid do not require more detail. Column 2 gives the dates over which the observations were made, Column 3 gives the number of actual runs made during that time span and column 4 gives the number of observations used. Column 5 is the range of phase angles over the full data range. If there are three values in the column, this means the phase angle reached a minimum with the middle valued being the minimum. Columns 6 and 7 give the range of values for the Phase Angle Bisector (PAB) longitude and latitude respectively. Column 8 gives the period and column 9 gives the error in hours. Columns 10 and 11 give the amplitude and error in magnitudes.

Acknowledgements

Thanks are given to Dr. Alan Harris of the Space Science Institute, Boulder, CO, and Dr. Petr Pravec of the Astronomical Institute, Czech Republic, for their ongoing support of all amateur asteroid. Also, thanks to Brian Warner for his continuing work and enhancements to the software program "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.

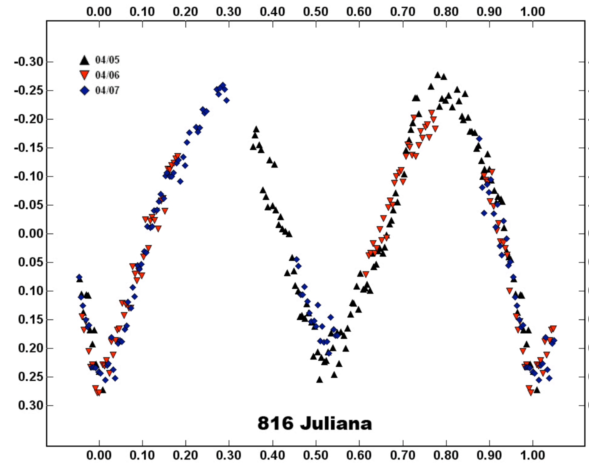


Figure 1: Lightcurve of 816 Juliana. Zero phase is equal to JD 2453466.845681 (corrected for light-time).

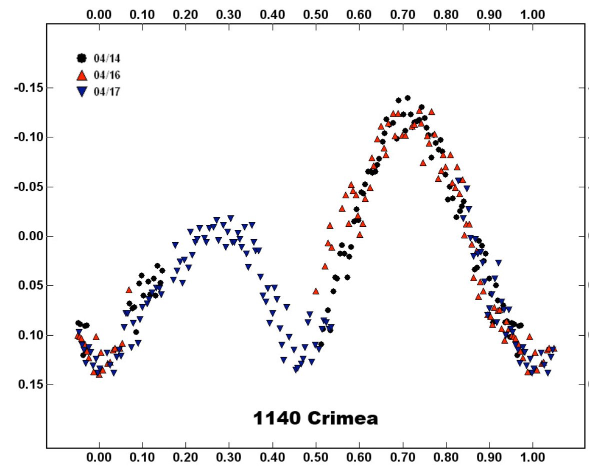


Figure 2: Lightcurve of 1140 Crimea. Zero phase is equal to JD 2453476.916172 (corrected for light-time).

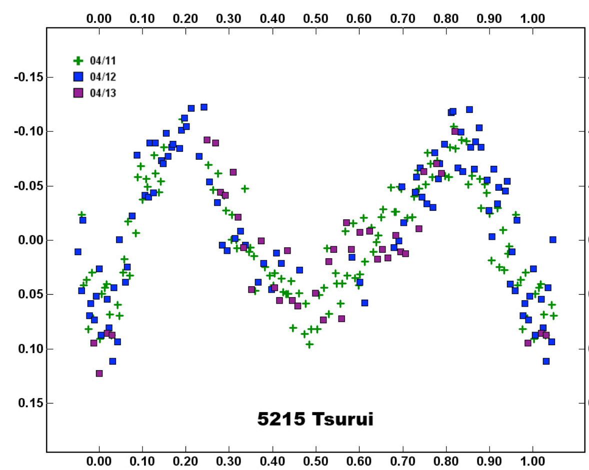


Figure 3: Lightcurve of 5215 Tsurui. Zero phase is equal to JD 2453473.691712 (corrected for light time).

Table I: Observation Results

Asteroid	Dates	Sess	Obs	Phase	L_{PAB}	B_{PAB}	Per (h)	PE	Amp	AE
816 Juliana	2004 04/05 – 07	3	310	7.5, 7.4	198.1	17.1, 17.2	10.58	0.02	0.52	0.03
1140 Crimea	2005 04/14 – 17	3	243	5.3, 5.5	200.8	13.6, 13.5	9.77	0.01	0.28	0.03
5215 Tsurui	2005 04/11 – 13	3	292	8.7	201.9	18.0, 18.1	3.81	0.01	0.24	0.03

References

Stephens, R. D. (2003). "Photometry of 2134 Dennispalm, 2258 Viipuri, 3678 Mongmanwai, 4024 Ronan, and 6354 Vangelis." *Minor Planet Bulletin* **30**, 46-48.

Stephens, R. D. (2005). http://home.earthlink.net/~rdstephens/default.htm.

Warner, B. (2005). "Potential Lightcurve Targets". http://www.minorplanetobserver.com/astlc.targets.

PERIOD DETERMINATION FOR 5878 CHARLENE

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

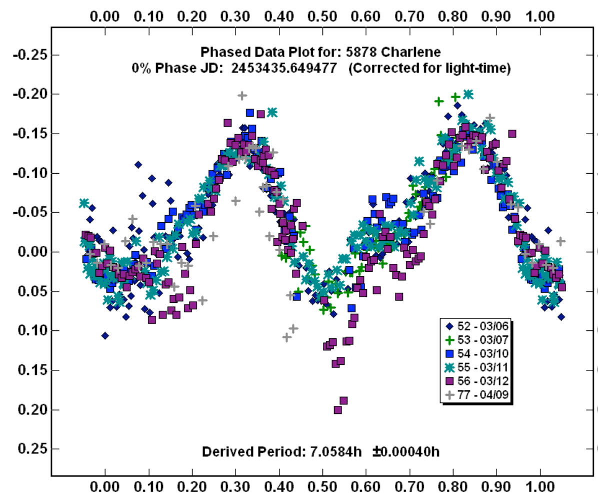
Robert A. Koff
980 Antelope Drive West
Bennett, CO 80102 USA
bob@antelopehillsobservatory.org

(Received: 18 April)

Minor planet 5878 Charlene was observed on six nights in early 2005 and found to have a synodic period 7.0584 ± 0.0004 hours and an amplitude of 0.20 ± 0.02 mag.

Minor planet 5878 Charlene was discovered 1991 Feb. 14 by E. F. Helin at Palomar (Schmadel, 2003). No previous period determinations have been reported (Harris, 2005). Charlene was observed at Antelope Hills Observatory, MPC Code H09, located near Bennett, Colorado, USA, at an elevation of 1740 meters for five nights during 2005 March 6-12 UT. The equipment and instrumentation have been described in a previous paper (Koff, 2004). The first author (FP) was a guest co-observer on the final two nights of observation and also reduced the lightcurve. Images were obtained through a clear filter within an IR cutoff of 700 nm, calibrated with dark frames and flat field frames. Lightcurves were prepared using the program "Canopus" which is based on the method developed by Dr. Alan Harris (Harris et al., 1989) which uses aperture photometry. Differential photometry was performed to obtain instrumental asteroid magnitudes. Night-to-night comparison star variation was compensated by manually shifting individual night magnitude scales to obtain a best fit. A synodic period of 7.063 hours was established on the basis of these five nights. The authors thank Dan Klinglesmith for additional telescope time April 9 at the Frank T. Etscorn Observatory, New Mexico Institute of Mining and Technology, Socorro, New Mexico, USA, to obtain another lightcurve, this one with an R filter. The purpose of this additional lightcurve was to reduce the formal error in the period by extending the span of observation. This procedure is recommended to all observers, when circumstances permit, even after the period is already definitively established.

A total of 734 images were used to obtain a bimodal rather than monomodal lightcurve of 7.0584 hours period with 0.20 magnitude amplitude. The formal error is ±0.0004 hour but a shift of at least 0.002 hours in phased period is required to increase the night-to-night scatter by an amount visually detectable. The minimum near phase 0.04 is wider and about 0.02 magnitude higher than the minimum near phase 0.50. The maximum near phase 0.82 is about 0.02 higher than the maximum near phase 0.30. There is a flat portion in the rise near phase 0.63 which does not occur in the rise out of the other minimum. The complete lightcurve was covered on four of the six nights, and these features appear on all of the individual nightly lightcurves. A quadrimodal period of 14.1162 hours was also tried in which alternate extrema are nearly identical and showed the respective features described above for the 7.0584 hour lightcurve. We consider the high symmetry between alternate extrema highly unlikely for a quadrimodal lightcurve and therefore claim the 7.0584 hour period is the correct one.



Acknowledgements. The authors thank Dan Klinglesmith for telescope time to obtain an additional lightcurve on April 9. The first author thanks Brian Warner for providing the Canopus program and instruction in its use that enabled the preparation of the lightcurve.

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

Harris, A. W. (2005). "Minor Planet Lightcurve Parameters," Updated 2005 Feb. 5. On the Minor Planet Center website: http://cfa-www.harvard.edu/iau/lists/LightcurveDat.html, or on the CALL website: http://MinorPlanetCenter.com/astlc/default.htm.

Koff, R. A. (2004). "Lightcurve Photometry of Mars-Crossing Asteroids 1474 Beira and 3674 Erbisbühl." The *Minor Planet Bulletin* **31**, 33-34

Schmadel, L. D. (2003). "*Dictionary of Minor Planet Names*," 5th edition, published by Springer-Verlag, p. 495.

ROTATIONAL PERIOD DETERMINATION FOR 62 ERATO AND 165 LORELEY

Russell I. Durkee
5213 Washburn Ave. S.
Minneapolis, MN 55410

(Received: 25 April Revised: 22 August)

Lightcurve period and amplitudes for 62 Erato and 165 Loreley were measured at the Shed of Science Observatory in late 2004 and early 2005. The synodic period and amplitude of 62 Erato are found to be 9.22 ± 0.02 hr and 0.15 mag. The results for 165 Loreley are 7.22 ± 0.01 hr and 0.09 mag.

The Shed of Science Observatory is located in Minneapolis, Minnesota at an elevation of 271 meters. The observatory utilizes a 0.35 meter Schmidt-Cassegrain telescope operating at f8.6 with a SBIG ST10XE CCD camera binned 3x3, resulting in an image scale of 1.4 arc seconds per pixel. All observations were unfiltered. Asteroid 62 Erato was selected for observation from the CALL website operated by Brian Warner. In September, 2004, Ellen Howell and Mike Nolan of Arecibo Observatory posted a request on the Minor Planet Mailing List for a number of asteroid lightcurves. Asteroid 165 Loreley was included on that list.

62 Erato. Over three consecutive nights in January 2005, 675 observations were used to derive the synodic period of 9.22 ± 0.02 hours with an amplitude of 0.15 ± 0.01 magnitude, as shown in the figure. The lightcurve is not bimodal and is characterized by three maxima and three minima. Harris et al. (1992) estimated a period somewhat greater than 8 hours. However, Alvarez-Candal et al. (2004) recently reported a period of 5.675h based on an incomplete lightcurve. The current data were plotted with a period of 5.675h and was found to be completely incompatible with the Alvarez-Candal et al. result. In addition, the period spectrum based on the current data strongly supports the 9.22 hour period; however, a 13.82h solution cannot be ruled out. Measurements made during the same time period by Goncalves and Behrend (2005) also support the 9.22 hour period solution.

165 Loreley. Previous lightcurve measurements of Loreley by Schober et al. (1988) indicated a 7.22h period. Harris et al. (1991) also reported a 7.22h period. Roy and Behrend (2004) reported an 8.5h period. Our current data supports the 7.22h solution. The mismatch at 0.05 phase initially led to a slightly longer solution of 7.88h; however, the period spectrum from the current data does not clearly favor a single solution. On the other hand, the period spectrum of Harris et al. (1991) strongly indicates a 7.22h period. In light of the ambiguity in the current data, the 7.22h solution is favored, and shown in the figure. The mismatch at 0.05 is not explained in our data and further observations could be helpful.

Acknowledgements. Many thanks to Brian Warner for his "Canopus" software which was used to process the data and create the lightcurves. Also, thanks to Alan Harris of the Space Science Institute for his valuable input and for providing Fourier analysis from earlier observations of 165 Loreley.

References

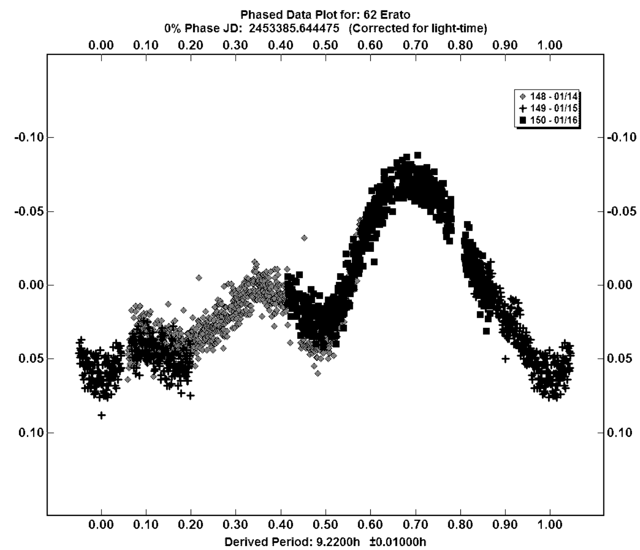
Alvarez-Candal, A., Duffard, R., Angeli, C., Lazzaro, D., and Fernandez, S. (2004). "Rotational lightcurves of asteroids belonging to families." Icarus **172**, 388-401.

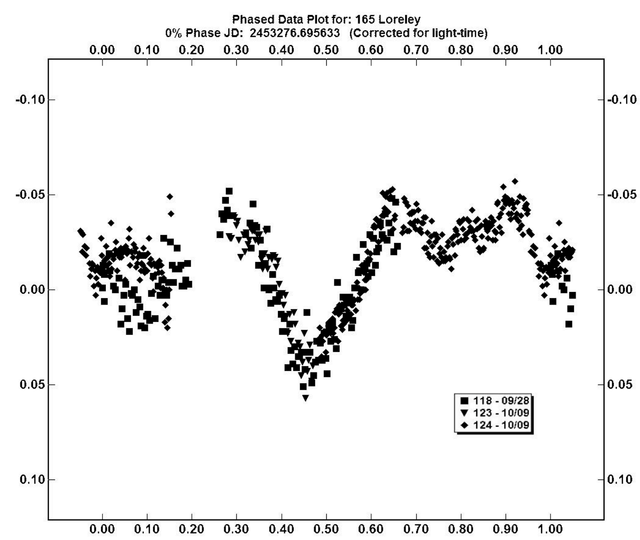
Goncalves, R., and Behrend, R., (2005). "(62) Erato" http://obswww.unige.ch/~behrend/page1cou.html.

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

Roy, R., and Behrend, R., (2004), "(165) Loreley" http://obswww.unige.ch/~behrend/page1cou.html.

Schober, H.J., Di Martino, M., and Cellino, A. (1988). "165 Loreley, one of the last large "unknown" asteroids." Astronomy and Astrophysics **197**, 327-330.





ASTEROID LIGHTCURVE RESULTS FROM MENKE OBSERVATORY

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

(Received: 11 April Revised: 28 April)

Lightcurves for the following asteroids are reported: 295 Theresia, 463 Lola, 605 Juvisia, 656 Beagle, 691 Lehigh, 885 Ulrike, 899 Jokaste, 931 Whittemora, 1116 Catronia, 1120 Cannonia, 1185 Nikko, 2463 Sterpin, 2647 Sova, 4649 Sumoto, 6475 Refugium, (27496) 2000 GC125, and (42600) 1997 YF10.

The asteroid program at Menke Observatory has been described elsewhere (Menke 2005, this issue). In brief, we use a C11 with an ST7E camera in an automated setup. The data are taken and the images are read using MaximDL to create text files of raw intensity values using a digital reference star plugin. These files are imported into Excel where the data are analyzed. The period is determined by inspection using a data folding process. Night to night calibration is done using a modified Landolt star reference process and/or manual offsets. The data are not light-time corrected. Virtually all targets were taken from the CALL web site lists (Warner 2005).

The results are presented in the table below. The lightcurve plots show data session dates as DXMMDDYY where X is our session number. Where appropriate, comments are provided on the individual results.

463 Lola. Note that very similar results were recently published by Bembrick (2005). These data were submitted to Aericibo in support of their radar work on this object.

605 Juvisia. I note that data sets D10 and D11 were supplied by another person whose name regretfully has been lost.

691 Lehigh. These data were taken under poor weather conditions and show substantial noise. While the derived period of 10.482 hr appears valid, an alternative period of 10.592 hr is not ruled out.

899 Jokaste. After the initial submission of this paper, the MPB editor noted that there was another paper by Don Pray that was pending, and that included different Jokaste data. At the editor's request, Don Pray and I combined the Pray data (7 sessions) from Jan-Feb 2005 with our data from Dec. 2003 (3 sessions). Using the combined data, we were able to determine the period with the high precision as noted in the results table. For clarity, the graph shows the Pray data as a single data series because there are relatively few points per session.

1116 Catronia. These data are relative only.

1185 Nikko. Very similar period results were recently published by Stephens (2005); however, the shape of the curve reported here is substantially different. We could find no explanation for the anomalous portion of the curve between phase=0.40-.55. Such a feature does not appear in the Stephens data taken in Nov. 2004, nor did it appear on the preceding or following sessions in this campaign (each of which covered about 1.5 full rotations).

(27496) 2000 GC125. These data were taken in 12/02-01/03 without calibration. The amplitude was small and the data noisy; however our analysis showed a period of 4.712hr. Petr Pravec kindly offered to review the data, and verified a period of 4.7097+/-0.0005 hr. which we have used.

(42600) 1997 YF10. These data are relative magnitude only.

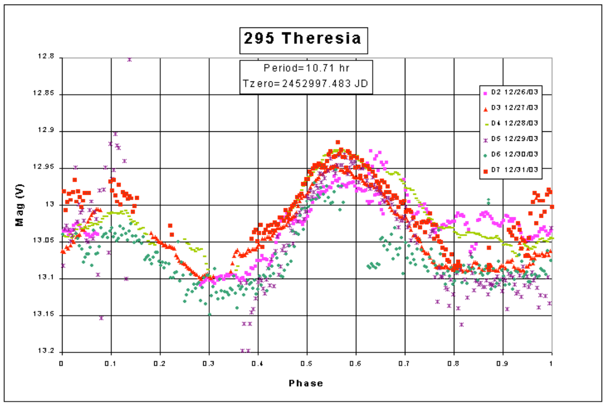
References

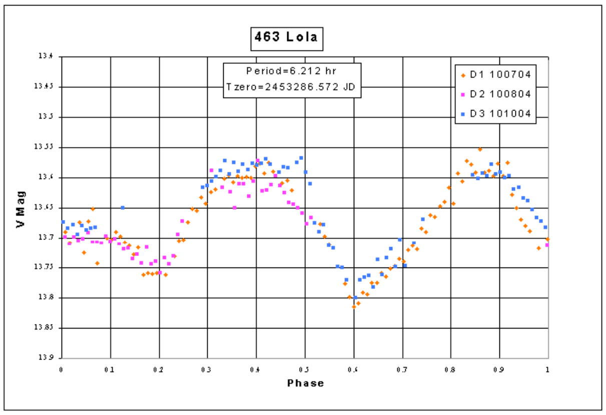
Bembrick, C. (2005). "Period Determination for 463 Lola." *MPB* **32**, 25.

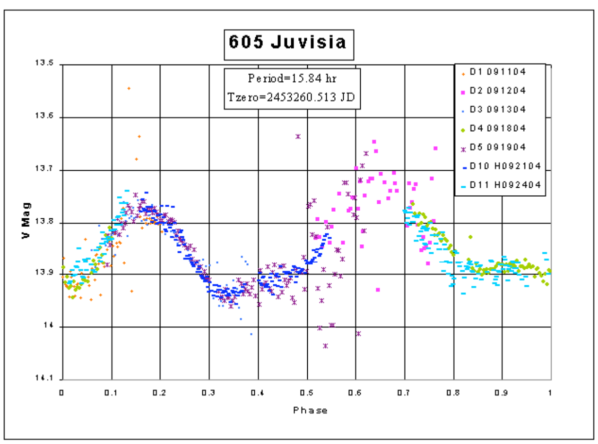
Stephens, R. D. (2005). "Rotational Periods of 743 Eugenisis, 995 Sternberga, 1185 Nikko, 2892 Filipenko, 3144 Brosche, and 3220 Murayama. *MPB* **32**, 27.

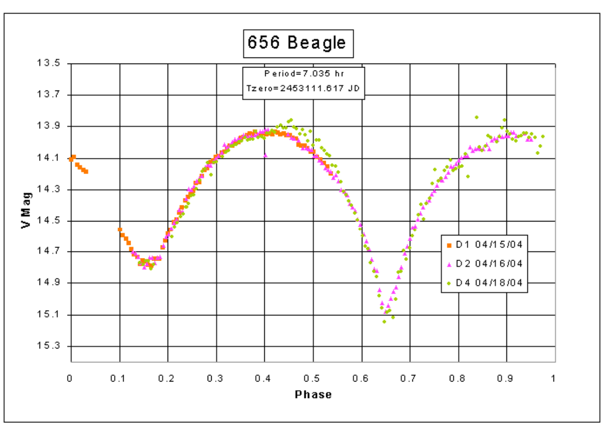
CALL website supported by Brian Warner. http://www.minorplanetobserver.com

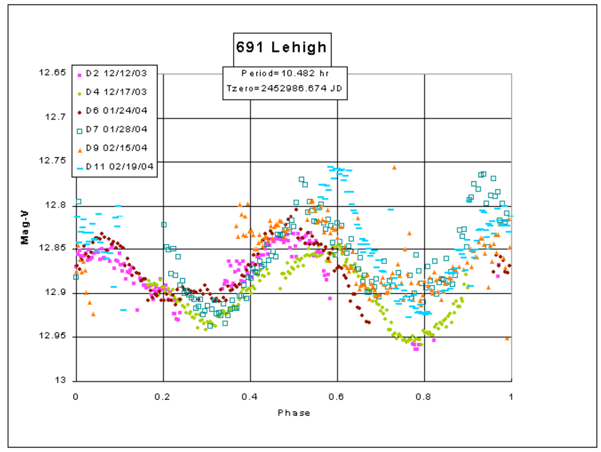
Number	Name	Period(hr)	Unc	Amp	Unc	DateStart	DateEnd	DateSpan	Sessions
295	Theresia	10.71	0.02	0.15	0.04	12/23/03	12/30/03	8	6
463	Lola	6.212	0.005	0.2	0.02	10/07/04	10/10/04	4	3
605	Juvisia	15.85	0.02	0.24	0.03	09/11/04	09/24/04	14	7
656	Beagle	7.035	0.003	1.2	0.1	04/15/04	04/18/04	4	3
691	Lehigh	10.482	0.003	0.12	0.02	12/12/03	02/19/04	68	6
885	Ulrike	4.90	0.05	0.55	0.05	09/20/04	09/20/04	1	1
899	Jokaste	6.2510	0.0002	0.25	0.05	12/02/03	02/27/05	446	10
931	Whittemora	19.20	0.01	0.2	0.05	01/07/04	01/13/04	7	4
1116	Catronia	8.83	0.01	0.09	0.02	12/06/03	12/16/03	11	3
1120	Cannonia	3.816	0.002	0.16	0.03	11/07/04	11/08/04	2	2
1185	Nikko	3.788	0.003	0.5	0.05	01/23/05	01/28/05	6	3
2463	Sterpin	15.40	0.01	0.3	0.05	12/24/04	02/10/05	47	5
2647	Sova	9.38	0.01	0.35	0.05	01/30/05	02/01/05	2	3
4649	Sumoto	26.31	0.01	0.3	0.05	12/10/04	01/01/05	22	6
6475	Refugium	8.01	0.01	0.45	0.05	11/09/04	11/11/04	3	2
27496	2000 GC125	4.7097	0.0005	0.10	0.03	12/22/02	01/12/03	21	5
42600	1997 YF10	7.771	0.001	0.9	0.1	01/08/05	01/28/05	21	6

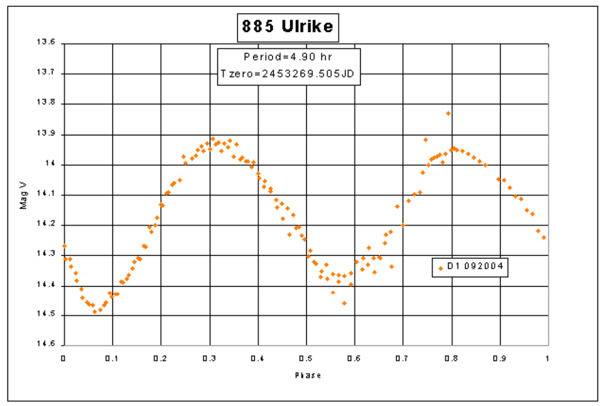

295 Theresia
Period=10.71 hr
Tzero=2452997.483 JD
D2 12/26/03
D3 12/27/03
D4 12/28/03
D5 12/29/03
D6 12/30/03
D7 12/31/03
Mag (V)
Phase

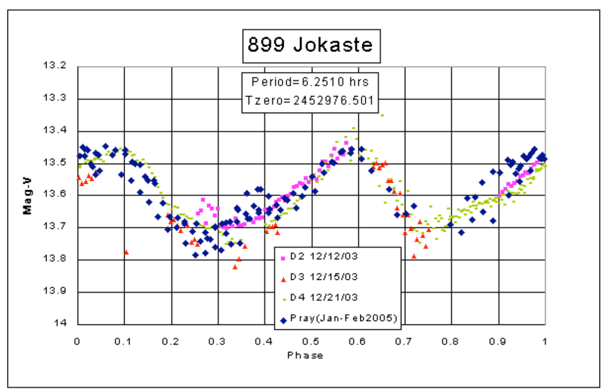

463 Lola
Period=6.212 hr
Tzero=2453286.572 JD
D1 100704
D2 100804
D3 101004
V Mag
Phase

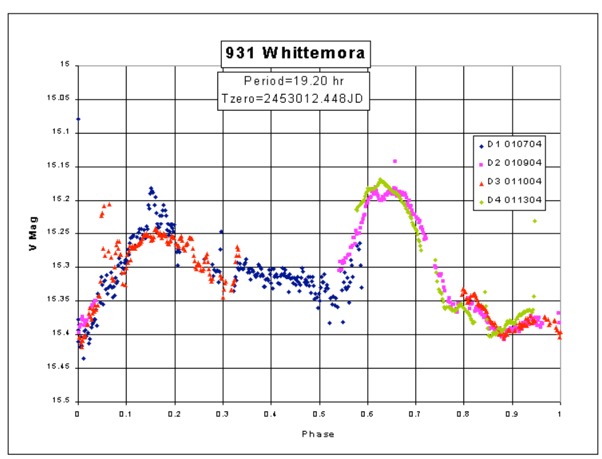

605 Juvisia
Period=15.84 hr
Tzero=2453260.513 JD
D1 091104
D2 091204
D3 091304
D4 091804
D5 091904
D10 H092104
D11 H092404
V Mag
Phase

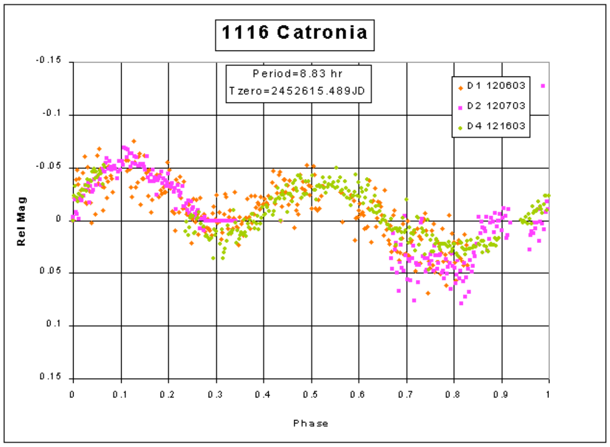

656 Beagle
Period=7.035 hr
Tzero=2453111.617 JD
D1 04/15/04
D2 04/16/04
D4 04/18/04
V Mag
Phase

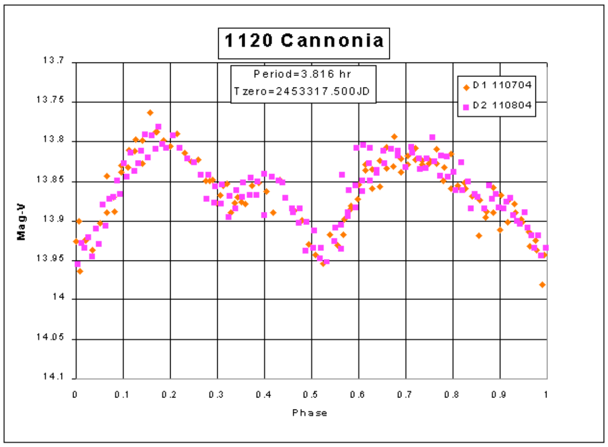

691 Lehigh
Period=10.482 hr
Tzero=2452986.674 JD
D2 12/12/03
D4 12/17/03
D6 01/24/04
D7 01/28/04
D9 02/15/04
D11 02/19/04
Mag-V
Phase

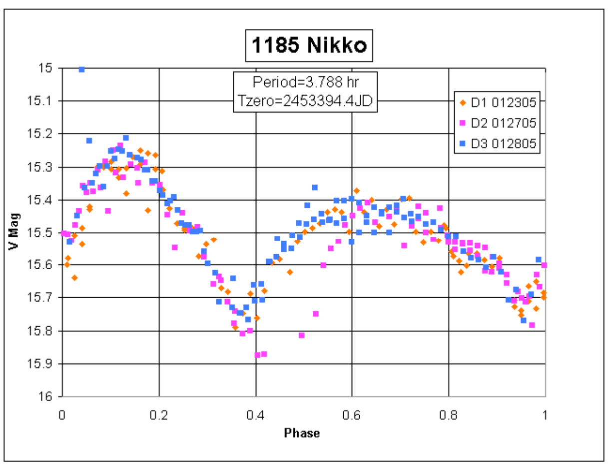

885 Ulrike
Period=4.90 hr
Tzero=2453269.505JD
D1 092004
Mag V
Phase

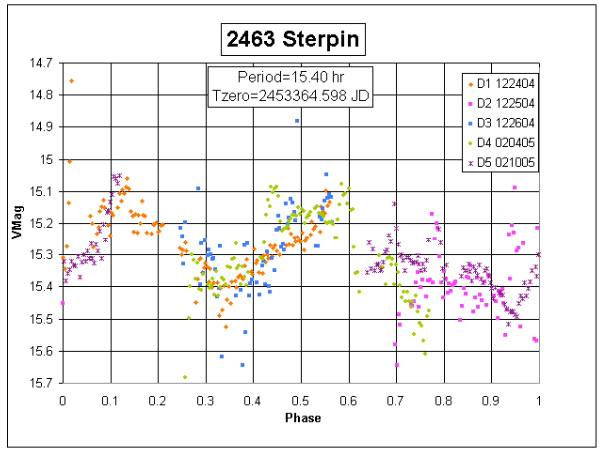

899 Jokaste
Period=6.2510 hrs
Tzero=2452976.501
D2 12/12/03
D3 12/15/03
D4 12/21/03
Pray(Jan-Feb2005)
Mag-V
Phase

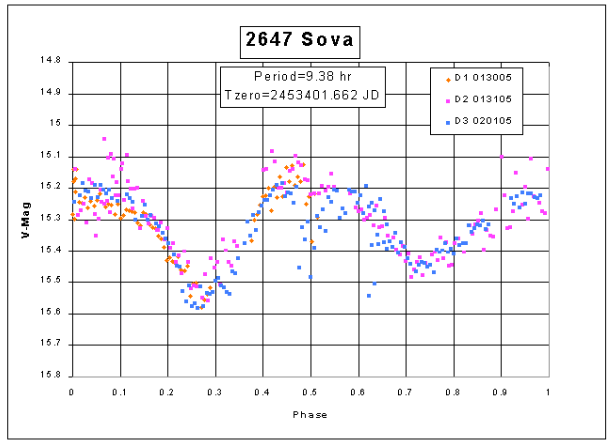

931 Whittemora
Period=19.20 hr
Tzero=2453012.448JD
D1 010704
D2 010904
D3 011004
D4 011304
V Mag
Phase

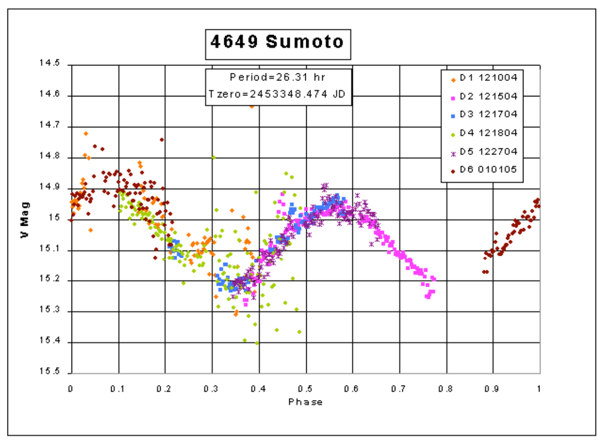

1116 Catronia
Period=8.83 hr
Tzero=2452615.489JD
D1 120603
D2 120703
D4 121603
Rel Mag
Phase

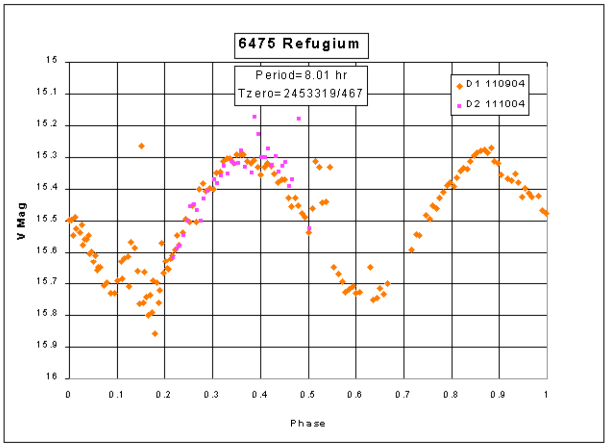

1120 Cannonia
Period=3.816 hr
Tzero=2453317.500JD
D1 110704
D2 110804
Mag-V
Phase

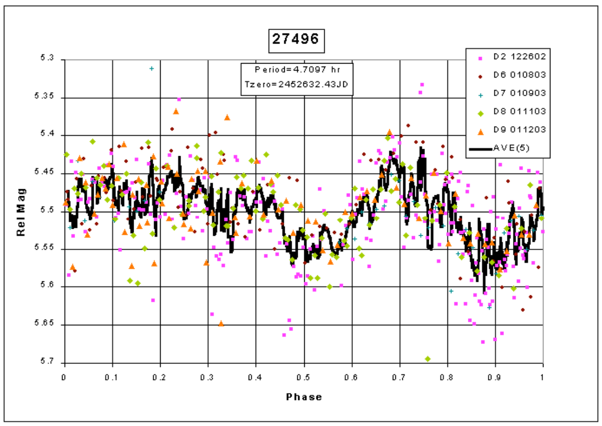

1185 Nikko
Period=3.788 hr
Tzero=2453394.4JD
D1 012305
D2 012705
D3 012805
V Mag
Phase

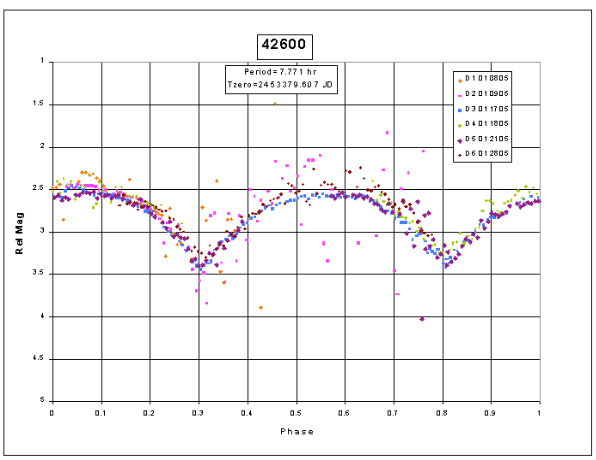

2463 Sterpin
Period=15.40 hr
Tzero=2453364.598 JD
D1 122404
D2 122504
D3 122604
D4 020405
D5 021005
VMag
Phase


2647 Sova
Period=9.38 hr
Tzero=2453401.662 JD
D1 013005
D2 013105
D3 020105
V-Mag
Phase


4649 Sumoto
Period=26.31 hr
Tzero=2453348.474 JD
D1 121004
D2 121504
D3 121704
D4 121804
D5 122704
D6 010105
V Mag
Phase







PROBABLE BINARY 3220 MURAYAMA

Akira Tsuchikawa
Sakuradanchi 1-1 Yanagida Noto
Housu Ishikawa, Japan
tsuchy@s5.dion.ne.jp

Seidai Miyasaka
Matsugaya 52-5-208
Hachioji, Tokyo, Japan

Hiromi Hamanowa
Hikarigaoka 4-43, Nukazawa
Shirasawa, Adachi, Fukushima, Japan

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Lightcurve observations made from three stations during 2004 Nov.7 to Dec.17 have revealed that 3220 Murayama is a probable binary asteroid. Primary's rotation period: 4.8595±0.0011 hr, amplitude: 0.13-0.15 mag. Secondary-to-primary mean diameter ratio: 0.4 The orbital period is unclear.

Yanagida Astronomical Observatory, MPC Code 417, is in the Noto peninsula, which is located in central Japan facing the Sea of Japan. The observatory utilizes a 0.6m, f/6 Ritchy-Chretien telescope with a Mutoh CCD camera. Co-observatories are Miyasaka Observatory, MPC Code 366, which utilizes a 0.36m f/8 Ritchy-Chretien telescope with a SBIG STL-1001E CCD, and Hamanowa Astronomical Observatory, MPC Code D91, which utilizes a 0.4m f/4.5 Newton telescope with a SBIG ST-8 CCD. All images were taken using an R-band filter. The images were measured with IRAF. The period analysis was done with cyclocode, developed by B. Dermawan (2003).

The lightcurve of 3220 Murayama was previously reported by Stephens (2005). He observed Murayama during Oct.15 to Oct.18 2004. He reported that its rotational period was 4.87 ± 0.01 hour and amplitude was 0.16 magnitude. Its lightcurve did not seem to be a binary system. However our lightcurve observations during 2004 Nov.7 to Dec.17 have revealed this minor planet is a probable binary asteroid.

Figure 1 is the lightcurve of Murayama. It includes all data, and the period is set to 4.8595 hr. Figures 2 and 3 are the short-period components. They are the primary's rotational lightcurve, derived from the original data by rejecting the deep extinction. The long-period lightcurve components are caused by occultation/eclipse events in the binary system. They are derived from the original data by subtracting the short-period component of each month. The data of Nov. 29 are included in both the November and the December analysis. Figure 4 shows that the only observed occultation event was in November. Figure 5 shows there were both occultation and eclipse observed events in December. All data are corrected for light-time. Zero phase is equal to 2453318.88332 JD. Because the orbital period is unclear, it is not possible to be certain of the long-period lightcurve components. We need more lightcurve observations to determine the orbital period. The next opposition of Murayama occurs in April 2006.

Acknowledgments

Thanks are given to Miyasaka, S. and Hamanowa H., for their support observation, to members of lightcurve mailing list for their advice and suggestions. Also many thanks to Dr. Petr Pravec, who helped me with the analysis and interpretation of this probable binary asteroid.

References

Dermawan, B. (2003). "CYCLOCODE Period Searching & Lightcurve Fitting Program; Ver. 3.6" http://www.toybox.gr.jp /mp366/lightcurve/cyclocode/cyclocode_doc_eng.pdf

Stephens, R. D. (2005). "Rotational Periods of 745 Eugenisis, 995 Sternberga, 1185 Nikko, 2892 Filipenko, 3144 Brosche, and 3220 Murayama." *Minor Plan. Bull*. **32**, 27.

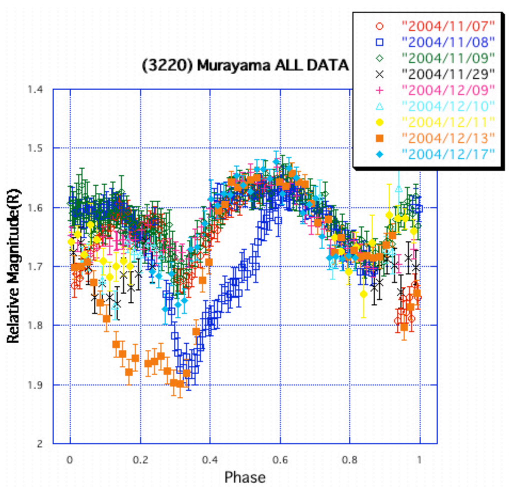


Figure 1. Lightcurve for 3220 Murayama containing all the data. The period used is 4.8595 hr.

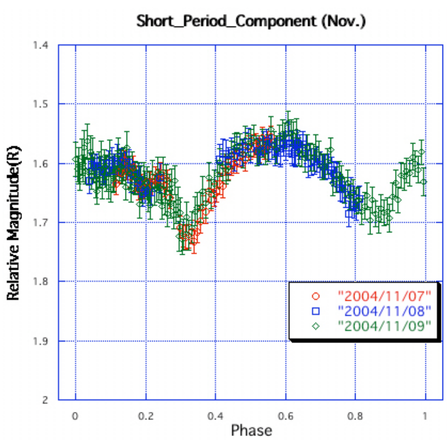


Figure 2. The 4.8595 hr short-period component in November.

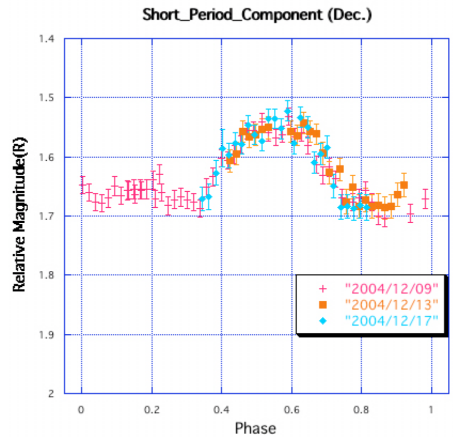


Figure 3. The 4.8595 hr short-period component in December.

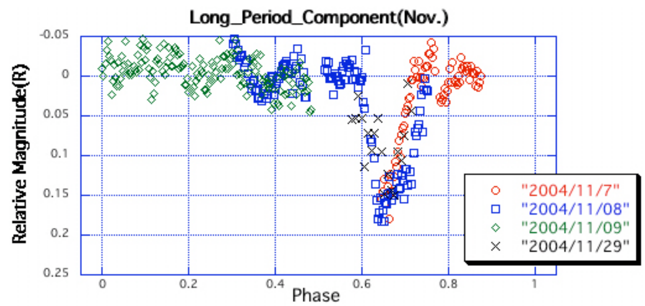


Figure 4. The long-period component derived from the original data by subtracting the short-period component in November. The period used for this figure is 13.135 hr.

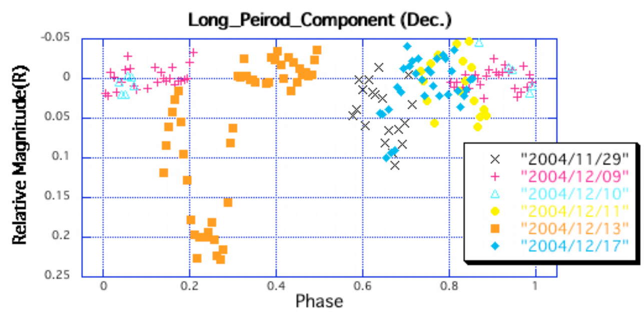


Figure 5. The 13.135 hr long-period component derived from the original data by subtracting the short-period component in December. The period used for this figure is 13.135 hr.

ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY – SPRING 2005

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

(Received: 12 July)

The lightcurves for the following asteroids were obtained at the Palmer Divide Observatory and then analyzed to determine the synodic period and amplitude: 157 Dejanira, 209 Dido, 630 Euphemia, 731 Sorga, 858 El Djezair, 1042 Amazone, 1952 Hesburgh, 3066 McFadden, 3094 Chukokkala, 4418 Fredfranklin, and 5775 Inuyama. The solutions for 157 Dejanira, 630 Euphemia, 858 El Djezair, and 1952 Hesburgh are marginally secure at best.

The Palmer Divide Observatory is equipped with three telescopes, a 0.5m Ritchey-Chretien and two 0.35m SCT telescopes. The 0.5m and one 0.35m use Finger Lakes Instruments CCD cameras with Kodak 1001E chips run at –30°C and 2x2 binning. The pixel scale is approximately 2.4 arcseconds per pixel on both telescopes. The remaining 0.35m SCT uses an SBIG ST-9 and Optec focal reducer that also gives a pixel scale of approximately 2.4 arcseconds with 1x1 binning. The camera was run between –5° and –10°C. All observations made for this paper were unfiltered (Clear). Exposure times were 120–180s, all unguided.

Targets were chosen by comparing the list of known lightcurve periods maintained by Harris and Warner (Harris 2005) against a list of well placed asteroids. Asteroid are often selected with the intent of removing the observational biases against faint objects (due to size and/or distance) as well as asteroids with lightcurves of small amplitudes, long periods, or complex nature. A high priority is also given to the Hungaria group as part of a long-term study of these inner main-belt objects. The images were measured using MPO Canopus, which employs differential aperture photometry to determine the values used for analysis. The period analysis was also done within Canopus, which incorporates an algorithm based on the Fourier analysis program developed by Harris (1989).

Results are summarized in the table below. The individual plots are presented afterwards. The data and curves are presented without additional comment except when the circumstances for a given asteroid require more details. Column 3 gives the full range of dates of observations while column 4 gives the number of actual runs made during that time span. Column 5 is the range of phase angles over the full date range. If there are three values in the column, this means the phase angle reached a minimum with the middle value being the minimum. Columns 6 and 7 give the range of values for the Phase Angle Bisector (PAB) longitude and latitude respectively. Column 9 gives the period error in hours and column 11 gives the amplitude error in magnitudes.

157 Dejanira. The period of just under 16h was nearly at a 1.5:1 commensurability with the interval between observations. Fortunately, runs were sufficiently long on three occasions to put some constraints on the solution.

209 Dido. This asteroid had been previously worked by Tedesco (1979), who found a period of 8.0 hours. Behrend et al (2004), found a period of 5.736h and amplitude of 0.25m. It was worked in 2005 in hopes of providing additional data for shape modeling.

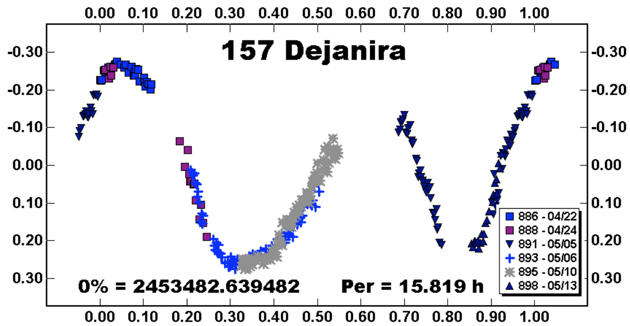
630 Euphemia. The period of 79.18h is the best fit that involved all sessions. Regardless, the fit does not appear to be very secure and so the solution must be viewed with some suspicion.

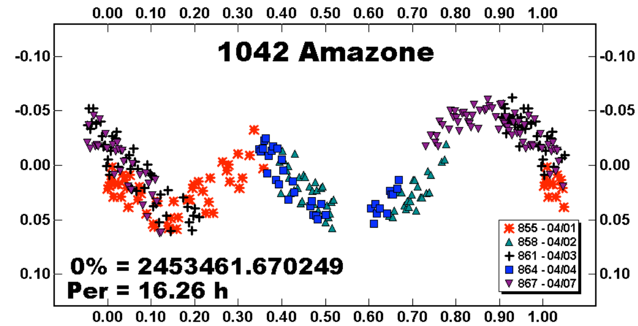
1042 Amazone. The author originally worked this asteroid in 2001 May. At that time, the period was reported on the CALL site (2004) to be 4.0h but with considerable uncertainty.

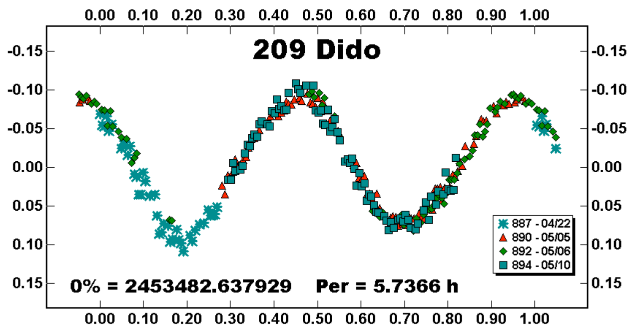
1952 Hesburgh. This was a case where the period was approximately half the interval between observation runs and so alternating parts of a bimodal curve, assuming the period is correct, were obtained on two instances of runs on consecutive nights. Since no run covered a maximum, the full amplitude of the curve could not be estimated.

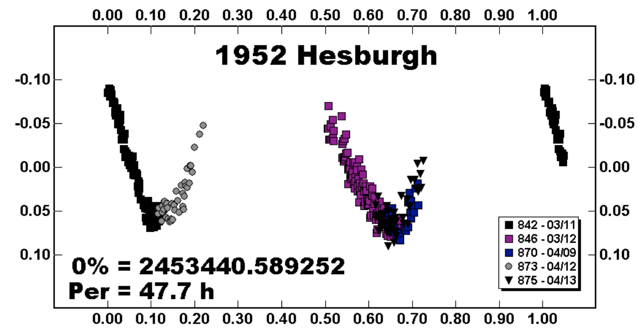
3066 McFadden. Wisniewski (1997) worked this asteroid for a single night, 1989 May 31. No period was reported but an amplitude of 0.04m was.

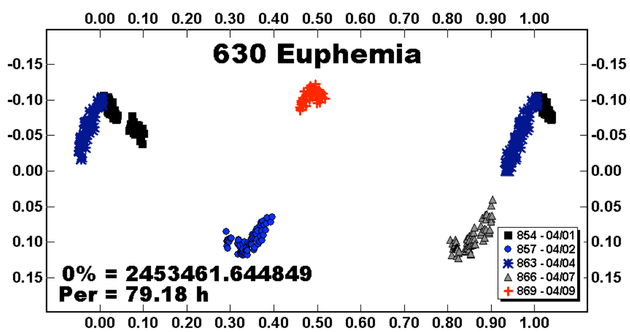
#	Name	Date Range 2005	Sess	Phase	L_{PAB}	B_{PAB}	Per (h)	PE	Amp	AE
157	Dejanira	04/22–05/13	6	19.1, 22.9	173.3, 177.0	13.3, 11.6	15.819	0.005	0.52	0.02
209	Dido	04/22–05/10	4	11.0, 15.6	181.7, 182.8	-0.9, -1.4	5.7366	0.0005	0.17	0.02
630	Euphemia	04/01–04/09	5	9.8, 11.6	185.6, 186.0	18.4, 18.3	79.18	0.2	0.2	0.02
731	Sorga	04/15–04/18	4	5.9, 6.8	189.8, 189.7	7.3, 7.1	8.184	0.005	0.52	0.02
858	El Djezair	04/19–04/20	2	7.1, 7.4	196.5	8.6	22.31	0.2	0.1	0.02
1042	Amazone	04/01–04/07	5	11.5, 12.5	158.1, 158.2	22.4, 22.0	16.26	0.02	0.10	0.02
1952	Hesburgh	03/11–04/13	5	10.2, 16.6	146.5, 148.5	16.3, 15.6	47.7	0.1	>0.18	0.02
3066	McFadden	06/07–07/01	7	9.7, 15.6	248.4, 249.0	19.5, 19.3	13.798	0.002	0.13	0.02
3094	Chukokkala	04/19–05/13	5	6.7, 15.6	199.6, 200.7	9.7, 11.0	8.3711	0.0004	0.33	0.02
4418	Fredfranklin	07/02–07/11	4	10.3, 11.1	281.0, 281.6	17.4, 17.6	4.8190	0.0006	0.24	0.02
5775	Inuyama	07/05–07/11	3	8.9, 10.2	278.2, 278.5	15.1	4.8345	0.0007	0.57	0.02

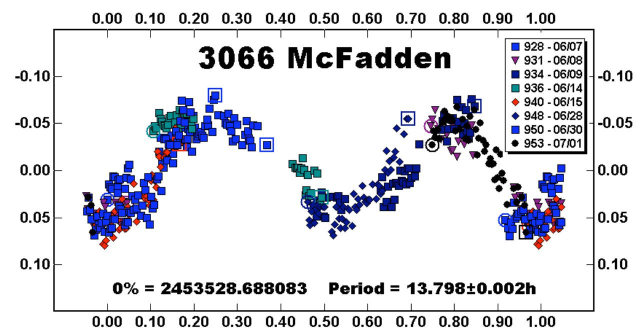

157 Dejanira
0% = 2453482.639482
Per = 15.819 h
886 - 04/22
888 - 04/24
891 - 05/05
893 - 05/06
895 - 05/10
898 - 05/13

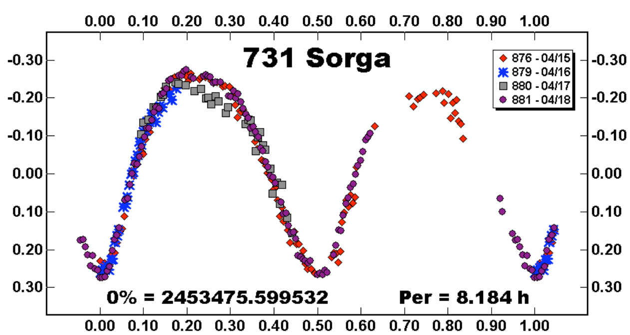

1042 Amazone
0% = 2453461.670249
Per = 16.26 h
855 - 04/01
858 - 04/02
861 - 04/03
864 - 04/04
867 - 04/07

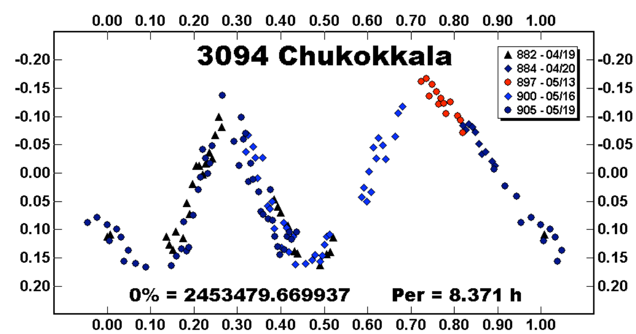

209 Dido
0% = 2453482.637929
Per = 5.7366 h
887 - 04/22
890 - 05/05
892 - 05/06
894 - 05/10

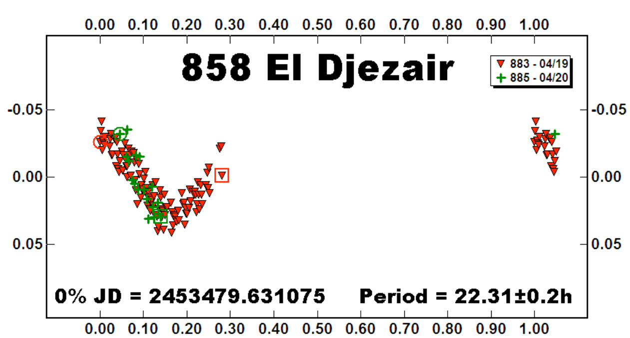

1952 Hesburgh
0% = 2453440.589252
Per = 47.7 h
842 - 03/11
846 - 03/12
870 - 04/09
873 - 04/12
875 - 04/13

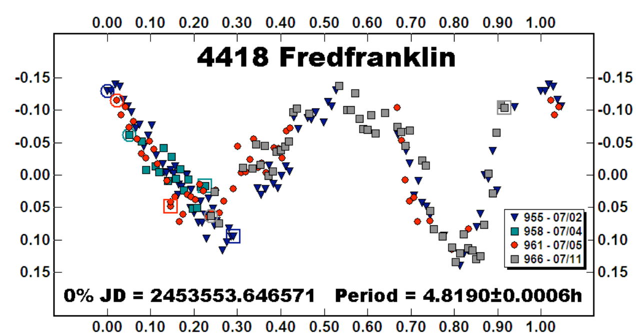

630 Euphemia
0% = 2453461.644849
Per = 79.18 h
854 - 04/01
857 - 04/02
863 - 04/04
866 - 04/07
869 - 04/09

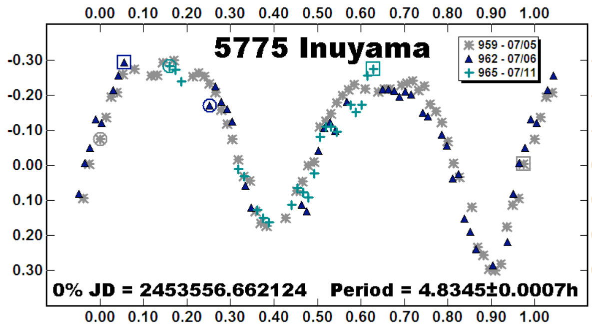

3066 McFadden
0% = 2453528.688083
Period = 13.798±0.002h
928 - 06/07
931 - 06/08
934 - 06/09
936 - 06/14
940 - 06/15
948 - 06/28
950 - 06/30
953 - 07/01


731 Sorga
0% = 2453475.599532
Per = 8.184 h
876 - 04/15
879 - 04/16
880 - 04/17
881 - 04/18


3094 Chukokkala
0% = 2453479.669937
Per = 8.371 h
882 - 04/19
884 - 04/20
897 - 05/13
900 - 05/16
905 - 05/19


858 El Djezair
0% JD = 2453479.631075
Period = 22.31±0.2h
883 - 04/19
885 - 04/20


4418 Fredfranklin
0% JD = 2453553.646571
Period = 4.8190±0.0006h
955 - 07/02
958 - 07/04
961 - 07/05
966 - 07/11



Acknowledgments

Thanks are given to Dr. Alan Harris of the Space Science Institute, Boulder, CO, and Dr. Petr Pravec of the Astronomical Institute, Czech Republic, for their ongoing support of all amateur asteroid photometrists and for their input during the analysis of some of the lightcurves presented here.

References

Behrend, R. (2004). Observatoire de Geneve web site, http://obswww.unige.ch/~behrend/page_cou.html

Collaborative Asteroid Lightcurve Link (CALL) (2004). http://www.minorplanetobserver.com/DATA/ submissions_results.htm

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, Alan W. (2005). "Minor Planet Lightcurve Parameters". On Minor Planet Center web site: http://cfa-www.harvard.edu/iau/lists/LightcurveDat.html

Tedesco, E.F.: 1979, PhD Dissertation, New. Mex. State Univ. 280pp.

Warner, B. D. (2003). "Lightcurve Analysis for (Several) Asteroids", *Minor Planet Bulletin* **30**, 21-24.

Wisniewski, W. Z., Michalowski, T. M., Harris, A. W., McMillan, R. S. (1997). Icarus **126**, 395-449; 1995, Lunar & Planetary Science XXVI, 1511-1512.

THE MINOR PLANET OBSERVER: A BUSY SUMMER

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

It happens every year: I go to the Society for Astronomical Science's (SAS) annual symposium in Big Bear, CA, and end up wanting to do even more things despite the fact I don't have enough time to do half of what I'm trying to do. The meeting this past May was particularly filled with temptations this year. I felt like the little kid peering into the candy shop window.

One of the highlights of the meeting was the presentation by Valerie Desnoux and Christian Buil. Christian, of course, is one of the experts on CCD imaging in the world, having written a classic book on the topic. He and Valerie are part of the Astronomical Ring for Access to Spectroscopy (ARAS). You can find the web site at http://astrosurf.com/aras/index1.htm. The group is dedicated to promoting spectroscopy by those with modest equipment. The work that is being done is nothing less than spectacular. Valerie and Christian's paper concerned Be Stars, bright hot stars with emission spectra.

Their talk was preceded by a mini-workshop by David Bradstreet, author of Binary Maker 3, which is a modeling tool that converts lightcurves of binary stars in to models. It never ceases to amaze me that so much can be learned from merely analyzing the change of light from an object over time. I know these are not related to asteroids but every once in awhile it's refreshing to look to other areas were smaller observatories can and are making strong contributions to science.

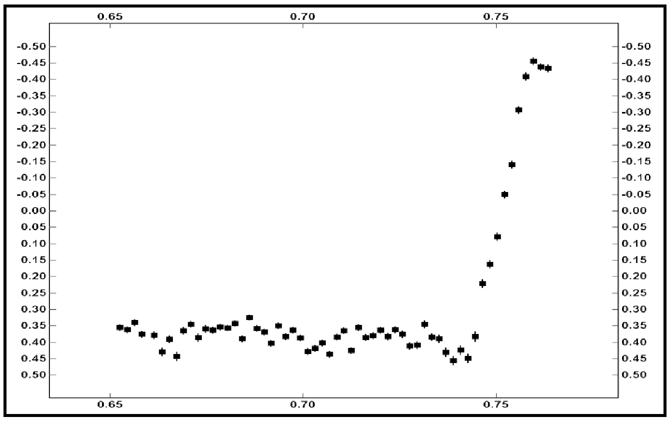
Of course, asteroids were not overlooked at the meeting. Petr Pravec traveled from the Czech Republic to present a paper on a study he and a group of others (OK, I'll say it – some are "amateurs") have been doing on binary asteroids, in particular those among the Near Earth Asteroid (NEA) population. Some very interesting findings have been made as a result of the study. A large paper is being prepared for publication in *Icarus* and some of the findings were presented at the Asteroids, Comets, and Meteors (ACM2005) meeting in Brazil in August. The initial study was expanded to cover inner main belt asteroids as well, i.e., Hungarias, Floras, and "Vestoids". Including these, especially the binary members found in recent years, yielded even more information for those studying the dynamics and evolution of asteroids.

There were also updates from Lance Benner from the Jet Propulsion Laboratory regarding radar imaging of asteroids. Support from the lightcurve and astrometry communities is critical to the success of the radar efforts. High-precision astrometry is need to confirm the predicted positions for pointing the Goldstone and Arecibo telescopes while lightcurve work can often confirm findings, e.g., binary asteroids, or determine that the asteroid is spinning too slowly to get good measurements. In the latter case, another target might be selected in order to maximize the results from limited observing time.

If you'd like to read the papers from the SAS meeting, you can go on-line at http://www.SocAstroSci.org. The proceedings are available as a large PDF. What you'll find in those is just some of many possibilities for contributing to science with even humble equipment. I know I've harped on this topic before but after attending meetings such as the SAS symposium, it's hard to imagine not wanting to do research with all the wonderful equipment that's available these days. The meeting refreshes my resolve to keep up my work, which has been concentrating on the Hungaria family (or group) at the urging of Alan Harris for the past couple of years.

Among the first of the Hungarias I measured was 70030 Margaretmiller, which I happened to discover and is named after my wife. How many of us get the opportunity to both find and name an asteroid for a spouse or close friend and then measure its rotation rate? The first part does wonders for building up what I call "Spousal Permission Units" – good will credits saved for a future time when one needs to ask for a particularly big favor or have a transgression overlooked. I like to say that my wife, a professional violist, is now also a "rock star." That gets a few more SPUs.

In July, there was the spectacular fireworks show on Comet $Temple_1$ after the Deep Impact probe hit it. Unfortunately, the comet was too low in the sky for me to turn my scopes on it and so I had to rely on accounts from friends around the world. Jerry Foote in Kanab, UT, sent me an amazing image showing the plume of material coming from the nucleus. Bob Koff of Bennett, CO, sent me a lightcurve he generated from his observations.



Lightcurve of Comet Temple1 at impact. Bob Koff, Antelope Hills Observatory, Bennett, CO.

That's good work for something less than 20° above the horizon. Many of those observing visually reported they didn't notice much of a difference. The CCD camera does not lie! Data are still pouring in and no doubt there will be plenty to fuel theories and papers for years to come. This brought back memories of the Shoemaker-Levy 9 collision with Jupiter. That I *did* get to see, or at least the aftermath: a large "black-eye" in the Jovian clouds. It is one of the astronomical events my wife remembers most, along with comets Hale-Bopp and Hyakutake.

So, just when things seem a little routine and there's seemingly nothing new going on, along comes a good meeting of the minds and another spectacular space probe event to keep things interesting. Of course, there's always trying to keep up with Spirit and Opportunity on Mars, Cassini around Saturn, and data mining on-line databases – among just a few other things. Almost all of this didn't require collecting a single photon of my own. It's a good thing, too. A very uncooperative Mother Nature brought my observing to a near standstill this summer. That candy store had a very thick window keeping me from the real treats.

Clear (and interesting) Skies!

A SIMPLIFIED METHOD FOR STANDARD STAR CALIBRATION

Richard P. Binzel
Department of Earth, Atmospheric, and Planetary Sciences
Massachusetts Institute of Technology
Cambridge, MA 02139

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Calibration of asteroid lightcurves to the standard magnitude system is often lacking due to the perceived difficulty. However, reasonably good calibration can be achieved through a simple method if standard star choices and measurements are made strategically. Using standard stars matching asteroid colors and performing calibration measurements at similar airmass values reduces the effects of most correction terms, allowing much simplification in the reductions.

[Preamble: The method described here has been long utilized by experienced practitioners. As the method is self-apparent, it is seldom described. The description offered here is hoped to be useful to new observers.]

CCD imaging provides a powerful technique for measuring asteroid lightcurves through differential photometry between the asteroid and comparison stars in the same image. One of the advantages of this simultaneous recording of the asteroid and the comparison stars is that lightcurve measurements can be obtained on nights that are less than perfect. Even if good conditions are present, there is a perceived difficulty in obtaining absolute photometric calibration on the standard magnitude system. The apparent difficulty in calibration often arises because no filter is used within the system, where either none is supplied with the CCD or the object being measured is near the limit of detection and the maximum photon counts are necessary for the best possible lightcurve precision. In other instances, absolute photometric calibration is not obtained because of the perceived time and effort required to determine extinction coefficients and color correction terms for the CCD and its filter combinations.

The purpose of this article is to describe a simplified method for quickly obtaining a reasonable photometric calibration of CCD lightcurves with respect to the standard magnitude system. Indeed, precise absolute calibration to 0.01 magnitude or better is an art form requiring the dedication of a substantial amount of observing time and painstaking reductions so that one derives first and second order extinction terms for the night(s) of observations as well as the color correction terms for their CCD system and filters. However, with some careful planning of the standard star measurements all of these effects can be minimized to the point of being "ignorable" if absolute calibration to within several percent (0.05 magnitude) is acceptable. For most asteroids, this level of precision is sufficient to substantially improve their catalogued magnitudes, where uncertainties of many tenths of a magnitude are pervasive.

There are three observational precepts for performing simplified calibrations of CCD lightcurves that require some advance planning and at least uniform sky conditions (if not 'photometric' conditions) over the time interval of the calibration measurements: **(1)** Determine the time(s) of night when you can measure the

asteroid and known standard stars at the same airmass.
(2) Choose standard stars having 'asteroid-like' colors.
(3) Obtain all of your asteroid and standard star calibration measurements in the same filter (V or R) as simultaneously as possible, where these filter measurements are well bracketed and linked to "routine" points as normally measured in the lightcurve. In some cases, the calibrations may even be performed using no filter at all.

To satisfy the first two observational precepts, my personal preference has always been to use standards from Landolt (1983). [Warner (2003) also provides a Landolt list and finder charts.] These standard stars are grouped at hourly intervals of right ascension and are located along the celestial equator, thus accessible to both northern and southern hemisphere observers. For the first precept, in the case where your target transits at a higher altitude (lower airmass) than the standard stars:
1a) Determine the airmass value for a star on the celestial equator when it crosses the meridian of your observatory. For most mid-latitudes, this is an airmass value around 1.3.
1b) Determine the time(s) when the asteroid you are observing will be at this airmass.
1c) Determine which Landolt standard star group(s) will be closest to the meridian at the time(s) determined in the preceding step.
In the case where the asteroid target transits at a greater airmass than the standards, e.g. a northern hemisphere observer tracking an object below the celestial equator, the first set of steps becomes:
1a) Determine the airmass value for your target asteroid when it crosses the meridian of your observatory.
1b) Determine the time when the target asteroid transits the meridian of your observatory.
1c) Determine which Landolt standard star group(s) will also be at this same airmass when your target object transits.
A very useful tool to do this automatically has been developed by Dr. Stephen M. Slivan (MIT). See the 'Airmass plot calculator' available at www.koronisfamily.com.

Once you have determined which group of Landolt stars can satisfy the first precept, you must make further selections to satisfy the second observational precept:
2) Select 2-5 Landolt stars within this group that have the best match to 'asteroid colors.' (Depending on the field of view of your system, many Landolt stars may be imaged simultaneously.) The stars you utilize for your calibration should have V-R magnitudes within the range of 0.3 to 0.6, or as close as possible to this range. (The Sun has V-R=0.36 in the Kron-Cousins system used by Landolt, and most asteroids are similar in color, or slightly redder, giving asteroids similar or slightly larger V-R values.) As noted above, the purpose of picking standard stars similar in color to the asteroid is so that second-order color correction terms may be reduced as much as possible. For the method described here, these color terms are ignored completely. Thus the closer the match between the asteroid and standard star colors, the lower the overall calibration error that is introduced by ignoring the color correction terms.

What filter to use for your calibrations: V or R? Because absolute 'H' magnitudes for asteroids are based on the V magnitude system, the V filter is preferred. However, choose V for your calibrations only if you can achieve sufficient precision (0.05 mag. or better) in your instrumental magnitudes so that the uncertainty in your asteroid measurement is the same or smaller than the errors introduced by this simplification method. If you cannot achieve 0.05 mag. or better precision with the V filter, use R. If your object is too faint for 0.05 magnitude precision in R, then no filter at all (!) remains a viable option. The method should still work under the assumption the standard star colors match the asteroid, although in practice the precision is unlikely to be better than 0.10 mag. As noted above, this can still provide an improvement in many cases to the catalogued magnitude values for asteroids.

Having chosen the filter (or no filter) for your standard measurements, satisfying the third observational precept is the most fun – as this is where you get to work fast and work smart (or at least program your sequences to work smart) at the telescope. The steps given below assume a calibration to V (for ease of description) and that most of your *lightcurve* measurements are being made with a clear filter (or no filter) – as this is the way to achieve the best precision for individual points in a lightcurve. If your lightcurve is in the same filter as your calibrations, simply ignore the references to the 'clear' filter. Similarly, substitute 'R' in place of the 'V' filter, if using R.
3a) As the asteroid approaches to within 0.1 (or less) of the 'magic' airmass equal to that of your standard star field, begin to alternate lightcurve imaging measurements between the clear (c) and V filter. For example: cVcVcVc brackets the V measures within the routine lightcurve. Bracketing around the V measurements is very important.
3b) With the standard star field(s) now at the same (or within 0.1) airmass of the asteroid field, image the standard star field(s) in V. Take 3-5 exposures of sufficient integration time to achieve 0.01 instrumental magnitude precision within each exposure.
3c) Repeat steps **3a** and **3b** again, if the airmass remains within about 0.1 between the standard field and the asteroid. Otherwise, resume your regular lightcurve imaging routine. [Of course, if the standard star field(s) reach the 'magic' airmass before the asteroid, step 3b can and should precede 3a].

Reduction Step 1: Reduce your lightcurve relative to on chip comparison stars in the usual way. The only difference to your regular reduction procedure is to pay special attention to the lightcurve data points that bracketed your V filter measurements in observational step 3a. Let $<\Delta M>$ denote the average relative magnitude of these bracketing lightcurve data points, as plotted within your normally reduced lightcurve.
Reduction Step 2: For each standard star image, compute the value $V_s - v_s$, where V_s is the standard magnitude from the Landolt list and v_s denotes the measured instrumental magnitude of the star in the V filter image. For all of your chosen standards, compute the average of all individual $V_s - v_s$ measures. Denote this average as $< V_s - v_s >$.
Reduction Step 3: Calculate the instrumental magnitude, v_a, of each V filter measurement of the asteroid taken in observing step 3a, and denote their average as $< v_a >$.
Reduction Step 4. Using the results of reduction steps 2 and 3, compute the V magnitude of the asteroid, call it V_a, from: $V_a = < v_a > + <V_s - v_s >$. This value of V_a is an anchor point connecting your lightcurve to the V magnitude system.
Reduction Step 5: Use the results of reduction steps 1 and 4 to calculate: $Z = V_a - <\Delta M>$. The value of Z is the vertical shift needed to place your lightcurve on the standard system. For example: suppose V_a = 14.60 and $<\Delta M>$ = +0.25 (note the algebraic sign of $<\Delta M>$ is very important, and shown here explicitly). Then: Z = 14.60 – (+0.25) = 14.35. Adding the vertical shift value of Z to every relative magnitude value in your lightcurve places your lightcurve on the standard magnitude system. In this example, the bracketing clear filter measurements from observing step 3a, which give an average value $<\Delta M>$ of +0.25 in the relative magnitude, serve as the anchor. In the final

calibrated lightcurve plot, these data points reside at a V magnitude of 14.60.

The overall success and precision of this simplified approach is dependent upon on how closely each of the three observing precepts is followed. It is worth emphasizing that this method, as described, makes an implicit assumption that sky conditions are uniform. Obviously the better the photometric conditions, the better the result. One worthwhile check is to plot comparison star instrumental magnitudes versus air mass, where a linear relationship confirms the constancy of the night – particularly at the time of standard star calibration. Additional steps that add increasing complexity (with the benefit of improving the precision) include the assumption of some nominal extinction coefficient (say 0.1 magnitude/airmass or other value typical for your site) so that all of your measurements in observing step 3 have first order extinction removed as a source of error. (This also reduces some of the time pressure to make all measurements simultaneously at the same airmass.) Obtaining clear (c) filter images of the standard stars, so that ($v_s - c_s$) instrumental colors of the standards can be compared with the ($v_a - c_a$) instrumental color of the asteroid, may constrain the choice of standard stars to those that are most 'asteroid-like', reducing unknown color correction terms. Likewise, the scatter or trend revealed by making a plot of calculated standard star V_s - v_s values versus their V-R catalogue values can reveal a color term for your photometric system, or at least give a good indication of the overall precision you have likely achieved in your calibrations.

Acknowledgments

The author thanks Alan W. Harris for decades (time flies) of discussions on asteroid photometry, who with Brian Warner and Stephen Slivan, provided many important corrections and improvements as referees for this manuscript.

References

Landolt, A. U. (1983). "UBVRI photometric standard stars around the celestial equator." *Astron. J.* **88**, 439-460.

Warner, B. D. (2003). *A Practical Guide to Lightcurve Photometry and Analysis.* Bdw Publishing, http://www.MinorPlanetObserver.com.

LIGHTCURVE PHOTOMETRY OPPORTUNITIES OCTOBER-DECEMBER 2005

Brian D. Warner
Palmer Divide Observatory
17995 Bakers Farm Rd.
Colorado Springs, CO 80908

Mikko Kaasalainen
Rolf Nevanlinna Institute
P.O. Box 68 (Gustaf Hallstromin katu 2b, room A422)
FIN-00014 University of Helsinki
Finland

Alan W. Harris
Space Science Institute
4603 Orange Knoll Ave.
La Canada, CA 91011-3364

Petr Pravec
Astronomical Institute
CZ-25165 Ondrejov
Czech Republic
ppravec@asu.cas.cz

We present here three lists of "targets of opportunity" for the period 2005 October – December. The first list is those asteroids reaching a favorable apparition during this period, are <15m at brightest, and have either no or poorly constrained lightcurve parameters. These circumstances make the asteroids particularly good targets for those with modest "backyard" telescopes, i.e., 0.2-0.5m.

The goal for these asteroids is to find a well-determined rotation rate, if at all possible. Don't hesitate to solicit help from other observers at widely spread longitudes should the initial finding for the period indicated that it will be difficult for a single station to find the period. This could be for the fact that the period has a multiple almost exactly equal to the interval between observing runs or the period is long, i.e., 18 hours to several days.

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 moment of opposition can provide important information for those studying the "opposition effect", which is when objects near opposition brighten more than simple geometry would allow.

With current methods under common use, it's required to get several lightcurves spread from different apparitions in order to generate a model of the asteroid. The final list is those asteroids needing only a small number of lightcurves to allow Kaasalainen and others to work on a shape model.

We encourage anyone doing lightcurve work to publish their results in the *Minor Planet Bulletin* and, if nothing else, make the data available on a personal website. Previous issues have covered larger upload sites such as OLAF, SAPC, and the ADU. For more information about those sites, please contact Warner at the email address given above.

Lightcurve Opportunities

#	Name	Brightest Date	V	Dec	U	Harris Per.	Data Amp.
7760	1990 RW3	10 02.8	14.9	+02	0		
1016	Anitra	10 02.7	13.6	+04	2	5.964	0.30
7776	Takeishi	10 03.1	14.7	+21	0		
3283	Skorina	10 03.1	14.9	+07	0		
962	Aslog	10 03.5	14.8	+01	0		
1906	Naef	10 04.8	14.6	+08	0		
3994	Ayashi	10 06.1	14.6	+01	0		
2004	Lexell	10 06.1	14.4	+06	0		
5580	Sharidake	10 06.9	14.7	+05	0		
6249	Jennifer	10 09.6	13.9	+33	0		
3312	Pedersen	10 10.6	14.9	+11	0		
1967	Menzel	10 14.6	13.9	+04	0		
8400	Tomizo	10 15.6	14.4	-14	1	>20.	>0.1
1139	Atami	10 15.7	12.5	+15	2	>15.	>0.15
4324	1981 YA1	10 15.9	14.1	+22	2	26.5	0.63
15607	2000 GA124	10 16.0	15.0	-07	0		
2757	Crisser	10 16.9	14.5	+09	0		
2034	Bernoulli	10 21.1	14.5	+13	0		
2016	Heinemann	10 21.2	14.5	+11	0		
14257	2000 AR97	10 22.9	14.2	+07	0		
16403	1984 WJ1	10 23.5	13.8	+10	0		
29495	1997 WU7	10 23.9	14.8	+10	0		
5994	Yakubovich	10 25.0	14.5	+12	0		
31889	2000 FW35	10 25.4	14.9	-12	0		
14276	2000 CF2	10 26.1	14.0	+13	0		
8830	1988 VZ	10 28.2	15.0	+13	0		
15365	1996 HQ9	10 28.1	15.0	+15	0		
3583	Burdett	10 28.8	15.0	+13	0		
2839	Annette	10 28.8	13.6	+12	0		
1662	Hoffmann	10 29.3	13.9	+20	0		
31060	1996 TB6	10 29.9	14.8	+16	0		
831	Stateira	10 29.4	14.3	+08	0		
2335	James	10 29.4	14.8	+51	0		
2871	Schober	10 30.2	14.5	+15	0		
406	Erna	10 30.9	13.5	+21	0		
838	Seraphina	10 31.3	13.4	+20	2	16.2	0.30
2099	Opik	11 01.4	14.7	+15	2	9.3	0.7
4661	Yebes	11 02.0	15.0	+07	0		
6097	Koishikawa	11 02.8	14.9	+12	0		
3998	Tezuka	11 03.6	14.5	+22	0		
46354	2001 TY8	11 04.1	14.9	+16	0		
5565	Ukyounodaibu	11 04.8	14.6	-02	0		
15350	Naganuma	11 05.4	14.7	+12	0		
2266	Tchaikovsky	11 05.1	14.6	+18	0		
3899	Wichterle	11 06.9	14.5	+14	0		
2006	Polonskaya	11 07.0	14.1	+23	0		
5477	1989 UH2	11 07.9	14.6	+13	0		
35618	1998 HC149	11 07.9	14.9	+11	0		
1447	Utra	11 10.3	14.2	+19	0		
4914	Pardina	11 10.1	14.4	+27	2	4.142	0.23
14835	Holdridge	11 10.9	14.4	+22	0		
6086	1987 VU	11 11.4	15.0	+13	0		
4121	Carlin	11 11.5	14.5	+20	0		
1912	Anubis	11 15.1	14.7	+17	0		
27136	1998 XJ16	11 16.9	14.8	+05	0		
7775	Taiko	11 16.7	14.9	+24	0		
2774	Tenojoki	11 18.9	14.9	+30	0		
1771	Makover	11 18.4	13.5	+10	0		
27057	1998 SP33	11 21.9	14.9	+31	0		
2044	Wirt	11 22.2	14.0	+27	0		
2107	Ilmari	11 22.4	14.4	+16	0		
6153	Hershey	11 22.4	14.2	-01	0		
1600	Vyssotsky	11 22.7	12.8	+20	2	3.2	0.13
503	Evelyn	11 22.2	11.8	+19	2	38.7	0.5
7201	Kuritariku	11 27.1	15.0	+25	0		
712	Boliviana	11 28.1	10.5	+15	2	11.732	0.11
2781	Kleczek	11 30.5	15.0	+18	0		
1671	Chaika	12 03.3	13.6	+14	0		
16941	1998 GR7	12 04.0	15.0	+13	0		
1639	Bower	12 06.9	13.6	+37	2	12.5	0.15
4608	1988 BW3	12 06.5	14.6	+11	0		
34706	2001 OP83	12 07.2	14.2	+26	0		
2464	Nordenskiold	12 07.1	14.5	+24	0		
2545	Verbiest	12 07.6	14.8	+34	0		
2040	Chalonge	12 08.9	14.8	+37	0		
316	Goberta	12 09.9	13.3	+20	0		
3981	Stodola	12 09.0	15.0	+23	0		
3511	Tsvetaeva	12 11.9	14.9	+15	0		
1857	Parchomenko	12 11.9	14.0	+20	0		
481	Emita	12 13.5	11.3	+28	2	14.35	0.30
5096	Luzin	12 14.1	14.9	+36	0		
1412	Lagrula	12 20.9	14.5	+27	0		

Lightcurve Opportunities (cont'd)

#	Name	Brightest Date	V	Dec	U	Harris Per.	Data Amp.
2886	Tinkaping	12 24.6	14.9	+23	1	12.	>0.13
814	Tauris	12 24.5	11.9	+26	2	35.8	0.20
461	Saskia	12 27.2	13.8	+21	0		
1733	Silke	12 27.2	14.9	+16	0		
2372	Proskurin	12 29.1	14.8	+23	0		
3905	Doppler	12 30.4	14.9	+48	0		

Low Phase Angle Opportunities

#	Name	Date	PhA	V	Dec
1016	Anitra	10 02.6	0.22	13.7	+04
5567	Durisen	10 04.6	0.47	13.7	+06
114	Kassandra	10 05.7	0.70	12.9	-03
35	Leukothea	10 07.1	0.83	13.1	-07
171	Ophelia	10 07.1	0.67	13.5	-04
250	Bettina	10 09.0	0.46	13.2	-05
578	Happelia	10 14.7	0.54	12.5	+07
242	Kriemhild	10 16.0	0.51	13.0	+10
510	Mabella	10 18.2	0.25	12.7	+09
69	Hesperia	10 20.2	0.82	12.5	-08
721	Tabora	10 25.7	0.44	13.6	+11
419	Aurelia	10 26.0	0.64	12.0	+14
14276	2000 CF2	10 26.1	0.20	14.0	+13
2839	Annette	10 28.8	0.87	13.6	+12
448	Natalie	11 04.4	0.57	14.0	+17
19	Fortuna	11 04.5	0.34	8.9	+15
976	Benjamina	11 10.5	0.89	14.0	+20
332	Siri	11 11.1	0.48	12.9	+19
13	Egeria	11 11.8	0.51	11.7	-19
694	Ekard	11 11.9	0.25	11.2	+18
83	Beatrix	11 19.3	0.74	13.1	-21
753	Tiflis	11 21.1	0.17	13.9	-20
10	Hygiea	11 21.8	0.70	10.6	-22
503	Evelyn	11 22.1	0.59	11.8	+19
1600	Vyssotsky	11 22.7	0.31	12.8	+20
416	Vaticana	11 27.8	0.70	12.6	+24
1249	Rutherfordia	12 02.7	0.65	13.5	+23
514	Armida	12 03.1	0.61	13.0	+24
455	Bruchsalia	12 10.2	0.27	11.6	+24
241	Germania	12 12.2	0.25	13.1	-24
552	Sigelinde	12 18.1	0.07	14.0	+24
410	Chloris	12 19.0	0.64	12.4	-22
1687	Glarona	12 28.1	0.10	13.6	+23
1	Ceres	12 28.4	0.77	8.7	-26

Shape/Spin Modeling Opportunities

#	Name	Brightest Date	V	Dec	Per (h)	Amp.	U	
47	Aglaja	12 31.	12.9	+16	13.20	0.03-0.17	4	
51	Nemausa	10 04.1	10.5	+00	7.783	0.10-0.14	4	3
79	Eurynome	12 31.	12.6	-09	5.978	0.05-0.24	4	
93	Minerva	12 01.3	12.1	+33	5.982	0.04-0.10	4	
125	Liberatrix	12 31.	14.1	+03	3.968	0.29-0.71	4	
165	Loreley	12 21.4	12.4	+32	7.226	0.12-0.15	2	
173	Ino	12 31.	12.8	-16	6.163	0.04-0.11	4	
221	Eos	10 19.9	11.7	-04	10.436	0.04-0.11	4	
344	Desiderata	11 18.5	12.1	+24	10.77	0.17	3	
386	Siegena	10 13.0	10.7	-10	9.763	0.11	3	
416	Vaticana	11 27.8	12.6	+24	5.372	0.17-0.38	4	
419	Aurelia	10 25.8	12.0	+14	16.709	0.08	2	A
683	Lanzia	12 31.	13.4	+24	8.630	0.12	3	4
747	Winchester	12 31.	12.5	-20	9.402	0.08-0.13	4	

Note that the amplitude in the table just above could be more, or less, than what's given. Use the listing as a guide and double-check your work. Also, if the date is '1 01.' Or '12 31. ', i.e., there is no value after the decimal, it means that the asteroid reaches its brightest just as the year begins (it gets dimmer all year) or it reaches its brightest at the end of the year (it gets brighter all year).

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Nonmembers are invited to join ALPO by communicating with: Matthew L. Will, A.L.P.O. Membership Secretary, P.O. Box 13456, Springfield, IL 62791-3456 (will008@attglobal.net). The Minor Planets Section is directed by its Coordinator, Prof. Frederick Pilcher, Department of Physics, Illinois College, Jacksonville, IL 62650 USA (pilcher@hilltop.ic.edu), assisted by Lawrence Garrett, 206 River Road, Fairfax, VT 05454 USA (LSGasteroid@msn.com). Richard Kowalski, 7630 Conrad St., Zephyrhills, FL 33544-2729 USA (qho@bitnik. com) is Associate Coordinator for Observation of NEO’s, and Steve Larson, Lunar and Planetary Laboratory, 1629 E. University Blvd., University of Arizona, Tucson, AZ 85721 USA (slarson@lpl.arizona.edu) is Scientific Advisor. The Asteroid Photometry Coordinator is Brian D. Warner, Palmer Divide Observatory, 17995 Bakers Farm Rd., Colorado Springs, CO 80908 USA (brian@MinorPlanetObserver.com).

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

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

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

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The deadline for the next issue (33-1) is October 15, 2005. The deadline for issue 33-2 is January 15, 2006.