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# ROTATION PERIOD AND H-G PARAMETERS DETERMINATION FOR 1700 ZVEZDARA: A COLLABORATIVE PHOTOMETRY PROJECT

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The main-belt asteroid 1700 Zvezdara was observed from 2009 August - November in order to determine its synodic rotation period (P) and amplitude (A) as well as its absolute magnitude (H) and phase slope parameter (G). The following values were found: P = 9.114 ± 0.001 h; A = 0.10 ± 0.02 mag; H = 12.447 ± 0.019 mag; and G = 0.072 ± 0.019.

The main-belt asteroid 1700 Zvezdara was originally discovered at the Belgrade Astronomical Observatory (BAO) on 1940 August 26 by Serbian astronomer Pero M. Djurkovich using a photo-visual Zeiss refractor with two 16/80 cm photographic cameras. The object is named after Zvezdara hill where the BAO facilities have been located since 1932.

Since no rotation parameters for this object were previously determined, as noted by Warner et al. (2009), our initial intention was to determine a secure rotation period. An exceptionally favorable apparition in 2009 September, with the asteroid reaching $V \sim 13.5$, provided an excellent opportunity for systematic photometric observations using modest instrumentation. Higgins began recording observations on 2009 August 20 at Hunter Hill Observatory equipped with a 0.35-m Schmidt-Cassegrain telescope (SCT) working at f/4 and an SBIG ST-8E CCD. Baker independently initiated observations on 2009 September 18 at Indian Hill Observatory using a 0.3-m SCT reduced to f/6.2 coupled with an SBIG ST-402ME CCD and Johnson V filter. Benishek from the Belgrade Astronomical Observatory joined the collaboration on 2009 September 24 employing a 0.4-m SCT operating at f/10 with an unguided SBIG ST-10 XME CCD. Pilcher at Organ Mesa Observatory carried out observations on 2009 September 30 over more than seven hours using a 0.35-m f/10 SCT and an unguided SBIG STL-1001E CCD. As a result of the collaborative effort, a total of 17 time series sessions was obtained from 2009 August 20 until October 19. All observations were unfiltered with the exception of those recorded on September 18. *MPO Canopus* software (BDW Publishing, 2009a) employing differential aperture photometry, was used by all authors for photometric data reduction. The period analysis was performed using the same program.

The data were merged by adjusting instrumental magnitudes and overlapping characteristic features of the individual lightcurves. Various problems, such as adverse weather conditions and horizon obstructions, cut short many observing runs and so made linking the data sets difficult at times. Fortunately, a few long-duration sessions, such as the one obtained on September 30 by Pilcher, contributed greatly to the construction of the composite lightcurve. We found an initial period and then removed ambiguities associated with the lack of observations and uncertainty of the positioning of some shorter sessions relative to the others. This lead to a bimodal lightcurve with $P = 9.114 \pm 0.001$ h and amplitude $A = 0.10 \pm 0.02$ mag as the most favorable solution (based on the RMS error). In the lightcurve plot, observations are binned into sets of 3 with a maximum time interval of 5 minutes.

## Phase Curve and H-G Parameters

1700 Zvezdara reached phase angle of $\alpha = 0.17$ degrees at opposition on 2009 September 21. This provided a very good opportunity to measure the absolute magnitude ($H$) and phase slope parameter ($G$). Although no observations were obtained when $\alpha < 2.0$ degrees, we derived 23 individual phase curve data points. Details for all observations are summarized in Table I. According to the *MPO Asteroid Viewing Guide* (BDW Publishing, 2009b), the asteroid will not appear as bright again for 30 years. The phase curve was constructed with the H-G calculator feature within *MPO Canopus*. The standard V magnitudes for the asteroid and comparison stars were determined using the method derived by Dymock and Miles (2009). Their derived empirical formula calculates standard V magnitudes using the Sloan r’ and 2MASS J and K magnitudes for stars in the CMC-14 catalog. Selected images from all observing sessions were measured using *Astrometrica* software (Raab, 2009), including all images recorded on 2009 September 18 with a photometric Johnson V filter.

Although the asteroid's lightcurve amplitude was relatively small, the brightness variance due to the rotation was removed through visual inspection of the lightcurve. The difference in magnitude between a given point on the lightcurve on a given date and the mean magnitude was estimated. The size and direction of the correction was unique for each data point but in all cases the correction was small with a mean correction for all data points of less than 0.02 mag. Although we made no attempt to measure the possible difference in unfiltered chip response among the several cameras, we did apply a constant correction in the amount of 0.04 magnitudes to the observed standard magnitudes from the unfiltered observations. This correction had the effect of forcing the data point from the session recorded with the Johnson V filter to appear exactly on the phase curve line, presumably yielding a more accurate value for the absolute magnitude ($H$). Brightness variance due to changing orbital geometry was removed from the corrected observed standard magnitudes by calculating reduced magnitudes with the formula:

$$\mathrm{Vr} = \mathrm{Vo} - 5.0 \log(Rr)$$

where Vr is the reduced magnitude, Vo is the observed magnitude, $R$ is the Sun-asteroid distance, and $r$ is the Earth-asteroid distance, both in AU (Warner, 2007).

The absolute magnitude based on our observational data was found to be $H = 12.447 \pm 0.019$. The phase slope parameter was found to be $G = 0.072 \pm 0.019$. Observations were also made with an Ic filter at Indian Hill Observatory on the same night the images in V were recorded. The transformed color index of the asteroid was determined to be $V\text{-}I = 0.796$. The reduced magnitude error estimates are based primarily on the statistics contained in the *Astrometrica* log file (Table I).

A search for previous data in the literature yielded the following references. According to the Planetary Data System (2005), 1700 Zvezdara is a member of the X taxonomic class (Tholen 1989). In the Supplemental IRAS Minor Planet Survey list (SIMPS; Tedesco et al., 2002), the asteroid's absolute magnitude, albedo, and diameter are given as $V = 12.47$, $p_V = 0.0425$, and $D = 20.68$ km. We note that low albedo members of the X class are categorized as type P. Correlation studies of asteroids by Harris (1989) indicate members of the P class typically have albedo values of $p_V = 0.058 \pm 0.004$ and a mean phase slope parameter values of $G = 0.086 \pm 0.015$.

Based on the absolute magnitude derived from our observations and the albedo value from SIMPS, we calculate the diameter of 1700 Zvezdara to be 20.89 kilometers when using the formula:

$$\log D = 3.125 - 0.2H - 0.5*\log(p_V)$$

where $D$ is the diameter (km), $H$ is the absolute magnitude and $p_V$ is the geometric albedo in the V band (Warner, 2007).

## Acknowledgements

We wish to thank Brian Warner for his support for asteroid lightcurve collaborations and for the continued development of software that allows efficient data sharing. Thanks also to Richard Miles of the British Astronomical Association for his work in deriving the useful method for determining accurate standard magnitudes from CMC-14 catalog data and for guidance in using the method.

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| Date 2009 | Mid-UT (hh:mm) | Observer | Time Series (hr) | #Obs | Filter | Phase Angle (deg) | Reduced Magnitude | Error |
|---|---|---|---|---|---|---|---|---|
| Aug 20 | 15:51 | Higgins | 6.6 | 37 | C | -18.59 | 13.515 | 0.049 |
| Aug 27 | 16:31 | Higgins | 7.3 | 55 | C | -15.19 | 13.359 | 0.040 |
| Sep 11 | 11:37 | Higgins | short | | C | -6.69 | 13.035 | 0.040 |
| Sep 12 | 11:49 | Higgins | 6.6 | 42 | C | -6.05 | 12.999 | 0.045 |
| Sep 15 | 15:25 | Higgins | 7.9 | 54 | C | -4.08 | 12.866 | 0.045 |
| Sep 18 | 05:21 | Baker | 5.0 | 132 | V | -2.39 | 12.750 | 0.023 |
| Sep 24 | 22:03 | Benishek | 3.2 | 74 | C | +2.00 | 12.823 | 0.038 |
| Sep 26 | 21:42 | Benishek | 3.5 | 76 | C | +3.28 | 12.815 | 0.034 |
| Sep 28 | 21:36 | Benishek | 3.2 | 64 | C | +4.58 | 12.910 | 0.031 |
| Sep 30 | 06:09 | Pilcher | 7.3 | 256 | C | +5.45 | 12.963 | 0.020 |
| Sep 30 | 21:33 | Benishek | 3.3 | 72 | C | +5.86 | 13.021 | 0.036 |
| Oct 04 | 21:11 | Benishek | 3.5 | 71 | C | +8.37 | 13.057 | 0.028 |
| Oct 05 | 21:24 | Benishek | 3.2 | 68 | C | +8.99 | 13.143 | 0.034 |
| Oct 06 | 21:27 | Benishek | 3.2 | 72 | C | +9.60 | 13.095 | 0.038 |
| Oct 07 | 21:17 | Benishek | 2.7 | 63 | C | +10.20 | 13.184 | 0.045 |
| Oct 08 | 20:59 | Benishek | 3.1 | 78 | C | +10.80 | 13.205 | 0.044 |
| Oct 11 | 01:57 | Baker | 1.0 | 22 | C | +12.10 | 13.295 | 0.050 |
| Oct 19 | 01:41 | Baker | 4.1 | 76 | C | +16.48 | 13.540 | 0.120 |
| Oct 26 | 01:05 | Baker | short | | C | +19.82 | 13.580 | 0.027 |
| Oct 27 | 02:01 | Baker | short | | C | +20.29 | 13.595 | 0.018 |
| Nov 12 | 01:43 | Baker | short | | C | +26.04 | 13.839 | 0.067 |
| Nov 14 | 19:00 | Benishek | short | | C | +26.79 | 13.734 | 0.040 |
| Nov 18 | 19:45 | Benishek | short | | C | +27.78 | 13.964 | 0.059 |

Table I. 1700 Zvezdara observation details.

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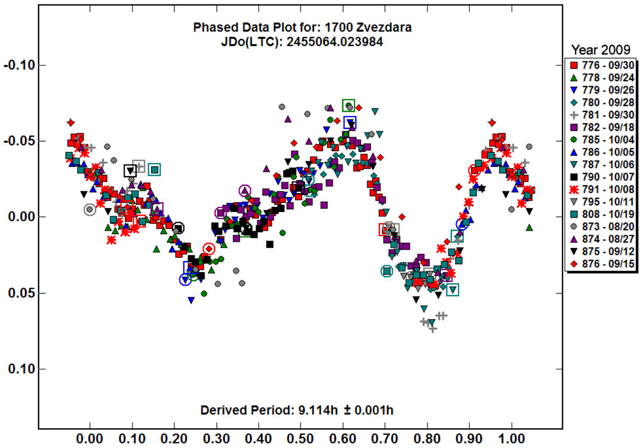

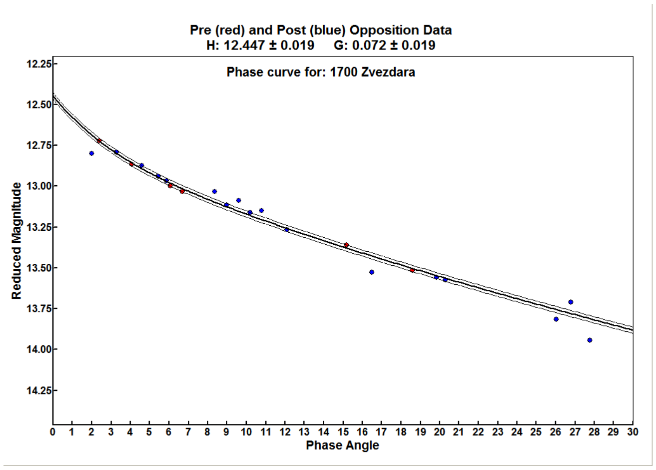

## COLLABORATIVE LIGHTCURVE PHOTOMETRY OF NEAR-EARTH ASTEROID (159402) 1999 AP10

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Near-Earth asteroid (159402) 1999 AP10 was observed over fifteen nights in 2009 September-October from several observatories. The resulting synodic period is 7.908 ± 0.001 h with amplitude 0.36 ± 0.02 mag. The V-R color index is 0.46 ± 0.02 mag, while the H magnitude is 16.6 ± 0.3 mag. This suggests an S-type asteroid with a diameter of 1.4 ± 0.3 km.

The near-Earth asteroid (NEA) (159402) 1999 AP10 was reported as a lightcurve photometry opportunity in the *MPB* (Warner et al., 2009a) and selected as a radar target for Arecibo from 2009 Oct 10. On 2009 Sept 23-24, after two sessions in V and R band from OAVdA, the probable rotation period was approximately 12 hours, i.e., in resonance with the Earth's rotation. Observations from different longitudes were required to resolve the period quickly. Following a message on the Minor Planet Mailing List (MPML) sent on Oct 1 by Carbognani, the authors started their collaboration. The equipment used for observations is described in Table I. The observations cover a span of 35 days with 25 sessions, for a total of 3548 data points (see Table II).

Before each session, the observers synchronized the computer's clock via Internet NTP servers to have a timing accuracy of less than one second. All images were calibrated with dark and flat-field frames. Exposure times were chosen to be as long as possible to maximize the overall signal-to-noise ratio (SNR) and to be compatible with the asteroid's sky motion: Max Exposure Time (min) = FWHM (arcsec) / rate of motion (arcsec/min).

Differential aperture photometry was performed with *MPO Canopus* (Warner, 2009b). Period analysis was done using *MPO Canopus* with the FALC analysis algorithm of Harris et al., (1989). Before starting analysis, the best sessions were selected based on signal-to-noise ratio. Sessions were aligned by adjusting the nightly zero point values using the CompAdjust form of *Canopus*. Our analysis shows a synodic period of 7.908 ± 0.001 h (Fig.1). This period is confirmed within error limits by *Peranso* (Vanmunster, 2007) using the ANOVA algorithm (Schwarzenberg-Czerny, 1996). The period spectrum covering 3-24 h (Fig. 2) shows the principal period and its harmonics, 2P and 3P, corresponding to 15.8 h and 23.7 h.

A separate analysis of the first and second half of the data shows no significant changes in the period or amplitude (within errors), despite the different phase angles, so we used the entire data set for our analysis. However, we found that the amplitude and the synodic period of the October 24 session (α = 68.6°, not included in our analysis) changed significantly compared to the other sessions (Fig. 3). For this session we estimate a phase shift of 0.030 ± 0.016 (from 0.798 to 0.828), based on the minimums of Oct. 7 and 24 as determined with a polynomial fit in *Peranso*.

For the lightcurve amplitudes (min to max), we found a value of $A = 0.36 \pm 0.02$ mag by taking the mean values from the several sessions as found by a polynomial fit in *Peranso*. We estimate an approximate lower limit on equatorial elongation of the asteroid as follows. The mean amplitude of 0.36 mag, observed at the mean phase angle of 35 deg, was corrected to zero phase angle using the empirical formula by Zappala et al. (1990):

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

where $\alpha$ is phase angle of observations, and $m$ is a slope parameter. Using $m = 0.03$/deg, which is the mean value for S-type asteroids (see below), we found $A(0°) = 0.18$. Assuming a triaxial ellipsoid, this gives a lower limit for the (a/b) ratio of $a/b = 10^{(A/2.5)} = 1.2$ (Warner, 2006). Despite the range of phase angles covered, the collected lightcurves were insufficient to do shape modeling from this single apparition.

### Color Index, H, and Diameter Estimate

1999 AP10 was observed from OAVdA Observatory in both R and V band, making it possible to estimate the V-R color index. For this purpose, we used the CMC14 catalogue and the method of Richard Miles and Roger Dymock (Miles and Dymock, 2009). In this method, the airmass of comparison and target are the same. The comparison stars are not Landolt stars but stars in the field of view belonging to the CMC14 catalogue with color indices J-K (from the 2MASS catalogue) between 0.3 and 0.7 (near solar values) and not belonging to GCVS (General Catalogue of Variable Stars). We manually selected the CMC14 reference stars with the help of the Aladin Sky Atlas (Bonnarel et al., 2000). Between the r' magnitude of CMC14 (Sloan DSS filter) and R/V standard magnitude, the linear relations are the following:

$$R = r' - 0.22 \qquad (2)$$

$$V = 0.6278(J - K) + 0.9947\, r' \qquad (3)$$

The standard deviations of the Landolt stars, from which Eq. 2 was obtained, are 0.02/0.04 mag for R and V.

Using (2) and (3), the result is V-R = 0.46 ± 0.02 (mean of 7 values, see Table III), and the individual values are essentially independent from the rotational phase. This value is typical of an S-type asteroid (Shevchenko and Lupishko, 1998). For an S-type asteroid, the mean $G$ value is 0.24 ± 0.01, while the geometric albedo is 0.20 ± 0.07 (Shevchenko and Lupishko, 1998). With these values, we estimated the absolute magnitude and the diameter, finding $H_V = 16.6 \pm 0.3$ mag and $D = 1.4 \pm 0.3$ km. Unfortunately, there were no V values for small phase angles, i.e., near 0°, which are required for a proper determination of $H$ and $G$. So, the uncertainty is still quite high, but it is still less than the error given in the JPL Small-Body Database Browser (http://ssd.jpl.nasa.gov/sbdb.cgi), $H_V = 15.986 \pm 0.494$ mag.

| Observer | Telescope | CCD |
|---|---|---|
| L.Franco | SCT 0.23-m f/5.5 | SBIG ST7-XME |
| A.Carbognani | RC 0.81-m f/7.9 | FLI PL 3041-1-BB |
| P.Wiggins | SCT 0.35-m f/5.5 | SBIG ST-10XME |
| B.W.Koehn[1] | ST 0.60-m f/1.8 | Loral 4K X 4K |
| R.Schmidt | CDK 0.32-m f/8 | SBIG STL1001E |

Table I. Observers and equipment list. [1]In the course of the Near-Earth Asteroid Photometric Survey (NEAPS).

| # | Date 2009 | Observer | Phase Angle | N.Obs | Filter |
|---|---|---|---|---|---|
| 1 | Sept 21 | B.W. Koehn | 20.1° | 22 | R |
| 2 | Sept 22 | B.W. Koehn | 21.0° | 82 | R |
| 3 | Sept 23 | B.W. Koehn | 22.0° | 118 | R |
| 4 | Sept 23 | A. Carbognani | 22.7° | 128 | V,R |
| 5 | Sept 24 | A. Carbognani | 23.6° | 121 | V,R |
| 6 | Sept 26 | L. Franco | 25.7° | 278 | C |
| 7 | Oct 2 | P. Wiggins | 31.7° | 72 | C |
| 8,9 | Oct 7 | P. Wiggins | 38.3° | 404 | C |
|  | Oct 8 | R. Schmidt | 39.6° | 80 | R |
| 10 | Oct 8 | P. Wiggins | 39.6° | 170 | C |
| 11,12 | Oct 9 | P. Wiggins | 41.2° | 306 | C |
| 13,14 | Oct 10 | P. Wiggins | 42.8° | 293 | C |
|  | Oct 12 | R. Schmidt | 45.8° | 74 | R |
| 15,16 | Oct 12 | R. Schmidt | 45.9° | 71 | R |
|  | Oct 12 | R. Schmidt | 46.1° | 212 | R |
|  | Oct 13 | R. Schmidt | 47.7° | 302 | R |
| 17,18 | Oct 13 | L. Franco | 49.1° | 323 | C |
| 19 | Oct 14 | A. Carbognani | 51.1° | 56 | V,R |
| 20 | Oct 15 | A. Carbognani | 52.9° | 40 | V,R |
|  | Oct 24 | L. Franco | 68.6° | 396 | C |

Table II. Observations list (sessions without ID are not included in the period analysis).

| Month/Day | UT | V | R | V-R | α (°) |
|---|---|---|---|---|---|
| 09 23 | 20:13 | 13.63 | 13.18 | 0.45 | 22.62 |
| 09 23 | 20:34 | 13.63 | 13.18 | 0.45 | 22.63 |
| 09 23 | 22:02 | 13.67 | 13.24 | 0.42 | 22.69 |
| 09 24 | 21:37 | 13.38 | 12.91 | 0.46 | 23.67 |
| 10 15 | 19:37 | 13.14 | 12.64 | 0.50 | 52.78 |
| 10 15 | 20:27 | 13.12 | 12.64 | 0.48 | 52.84 |
| 10 15 | 20:49 | 13.10 | 12.63 | 0.47 | 52.87 |

Table III. The V and R magnitude values, corrected for rotational phase with the 7.908 h period, used for mean color index and $H_V$ estimate. The last column shows the corresponding phase angle (OAVdA Observatory).

### Acknowledgments

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This research made use of the SIMBAD and VIZIER databases with the Aladin Sky Atlas that operates at CDS (Strasbourg, France), of GCVS maintained by Sternberg Astronomical Institute (Moscow, Russia), and of the NASA's Astrophysics Data System.

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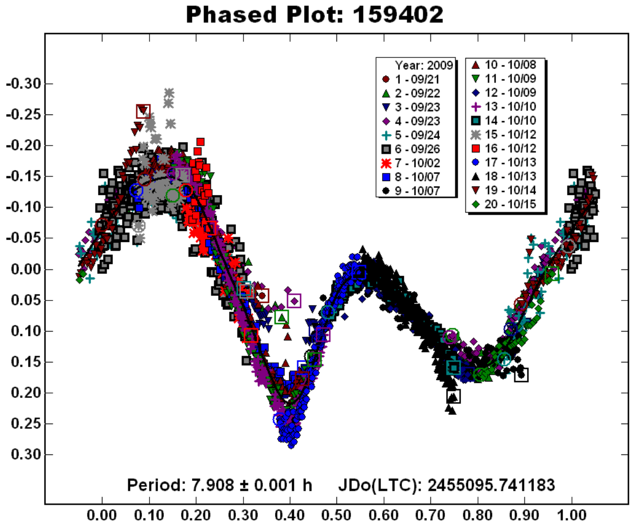

Figure 1.The lightcurve of (159402) 1999 AP10 shows a period of 7.908 h with an amplitude of 0.36 mag.

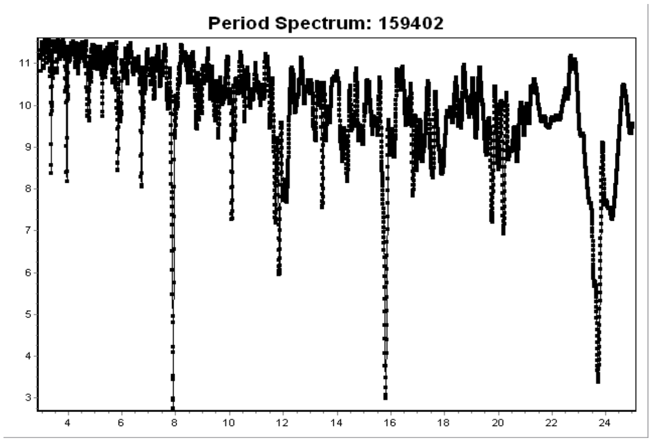

Figure 2. Period Spectrum show the principal period and the harmonics P/2 and P/3.

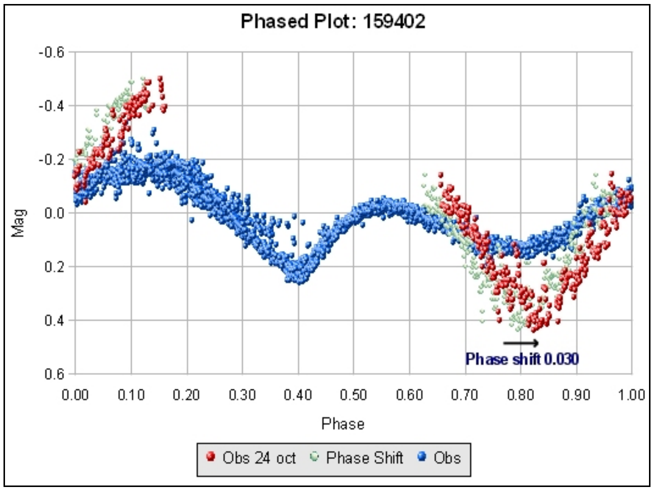

Figure 3. The session of October 24 (α = 68.6°) shows amplitude variations and a phase shift estimated as 0.030 ± 0.016.

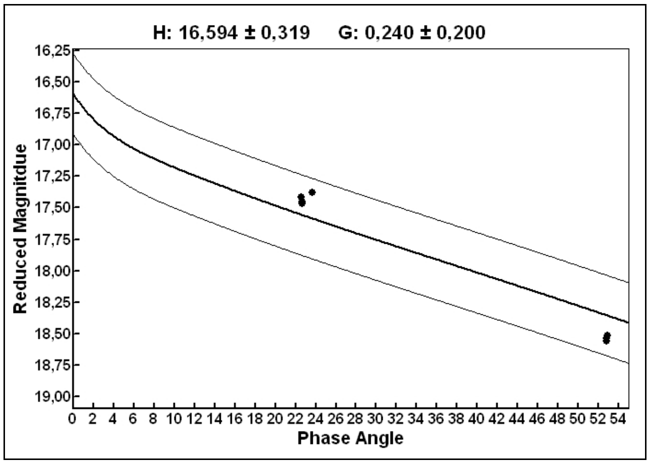

Figure 4. Visual reduced magnitude vs phase angle for $H_V$ estimate with fixed G (OAVdA Observatory).

# ANALYSIS OF THE LIGHTCURVE OF (217807) 2000 XK44: A TUMBLING NEA

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We report on our CCD photometric observations on the near-Earth asteroid (NEA), (217807) 2000 XK44. Our analysis shows that the asteroid is in non-principle axis rotation (NPAR) with the strongest harmonics in the frequency analysis corresponding to periods of 51.9 and 66.8 h.

Observations of the near-Earth asteroid (NEA), (17807) 2000 XK44 were made in 2009 November by Warner, Stephens, and Pray in support of planned radar observations. The equipment and basic image acquisition methods used by the authors have been previously described (see Stephens, 2006; Warner, 2009b). We linked our observations from night-to-night using the 2MASS (Skrutskie et al., 2006) to BVRI conversions developed by Warner (2007) and applied as described by Stephens (2008).

It became apparent after the first few observing runs that the lightcurve showed signs that the asteroid was in non-principal axis rotation (NPAR) and so the observers sought help from Petr Pravec who has developed software that can analyze multiple periods that are not additive. His analysis shows that the strongest harmonics correspond to periods of 51.9 and 66.8 h and PAR = –2 to –3. See Pravec et al, 2005, for a discussion of period analysis for tumbling asteroids and the PAR rating system.

These may be the actual periods of rotation and wobble (free precession), or they may be linear combinations of the true frequencies, e.g. $2*f_1 \pm 2*f_2$ (see Pravec et al. 2005 for further discussion of lightcurve analysis of NPA rotators). Unfortunately all of the observations were taken at close to the same longitude, so it was not possible to remove the commensurability of the observations with a 24-hour cadence. Observations from other longitudes might have allowed finding the true frequencies (periods) of the NPA rotation.

The results were communicated to observers at Arecibo and Goldstone. Results from their observations are pending. It may be that the combined data sets allow for a more definitive solution to the nature of the asteroid's rotational characteristics.

Some initial results from thermal observations obtained in coordination with the radar observations show the asteroid to be a type S (Howell, private communication). Assuming an albedo of 0.2 and the MPC value of H = 18.2, this yields a diameter of ~0.7 km. There are approximately 20 asteroids in the asteroid lightcurve database (LCDB, Warner et al, 2009a) that can be considered very likely to certain "tumblers." The sizes range from a few hundred meters to 52 km. What distinguishes this particular asteroid is the amount and quality of data that allowed establishing the two periods reported here.

## Acknowledgements

Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNX 09AB48G, by National Science Foundation grant AST-0907650, and by a 2007 Gene Shoemaker NEO Grant from the Planetary Society. The work at Ondrejov was supported by the Grant Agency of the Czech Republic, Grant 205/09/1107. This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by NASA and NSF.

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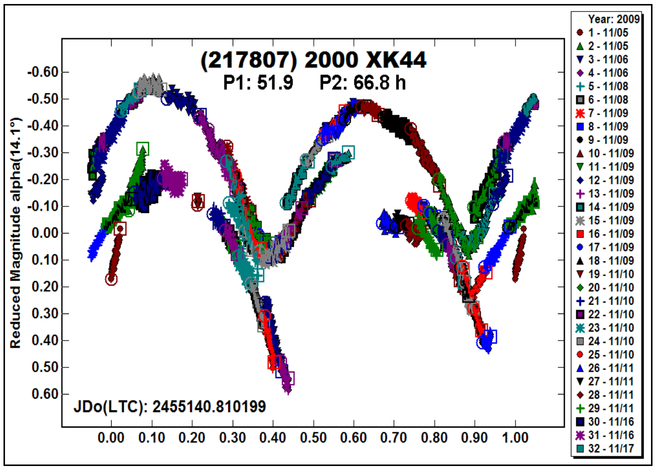

# LIGHTCURVE ANALYSIS OF ASTEROIDS 3567 ALVEMA AND 5421 ULANOVA

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Two main-belt asteroids without previously reported lightcurves were observed between 2009 September and December. Lightcurve parameters were found for 3567 Alvema (P = 11.542 ± 0.003 h, A = 0.17 mag) and 5421 Ulanova (P = 9.77 ± 0.01 h, A = 0.60 mag).

Main-belt asteroids 3567 Alvema and 5421 Ulanova were studied using two observatories. The majority of the observations were made at Gothers Observatory in the UK (MPC J03). A smaller but significant number were made using the robotic telescope facility provided by the Tzec Maun Foundation in New Mexico, USA (MPC H10). Gothers Observatory measurements were made using a 0.25-m Schmidt-Cassegrain with an f/3.3 focal reducer. The detector was a QHY6 Pro CCD featuring a 752 X 585 array of 8.6x8.3 micron pixels binned at 1x1. The resulting optical train produced an image scale of 1.69x1.63 arcsec/pixel. The camera was used with set point cooling of –10°C. All images were dark and flat field corrected. These observations were made unguided and unfiltered with exposures of 210 s. Automated computer control of the mount and CCD camera allowed unsupervised imaging for extended durations in excess of 8 hours. Typical FWHM of point sources was 4 arcsec for the reduced data sets. Further details can be seen at www.gothersobservatory.org.uk.

Observations at Tzec Maun were made using two different telescopes. The first was a 0.35-m Maksutov-Newtonian f/3.8 reflector. It was equipped with a SBIG ST-10XME giving an image scale of 1.05 arcsec/pixel. The second instrument was a 0.4-m RCOS Ritchey-Chretien telescope equipped with an SBIG STL-6303. This combination provided an image scale of 1 arcsec/pixel (binned 2x2). Both telescopes were operated remotely over the Internet from the UK. All images were made using a Johnson V filter and were dark corrected. The larger aperture of the remote telescopes was useful since they allowed photometry to be performed during the following lunation, when the objects had become too faint for the smaller instrument. These later data allowed significant reduction of the errors in the period of the lightcurve.

The asteroids were selected from the CALL lightcurve targets page (Warner, 2009). The targets were selected as those being of V < 16 and without a previously reported lightcurve. Preference was also given to targets with high declination and low angular motion, the second criteria allowing long integration times necessary to minimise noise with the relatively small aperture. Image calibration and differential photometry were undertaken using *Astrometrica* (Raab, 2009) and Carlsberg Meridian Catalogue 14 (Evans et al., 2002). Period determination was performed using *Peranso* lightcurve analysis software (Vanmunster, 2009) and Microsoft *Excel*. The selected targets and the parameters at the first observation of their respective campaigns are shown in Table I. Composite lightcurves collected for the objects are shown in Figures 1 and 2.

3567 Alvema. This object was imaged 211 times over 7 nights (2009 October 13, 20, 22; December 5, 12, 16, 17). The rotational period solution was initially difficult to determine until the obvious deep minimum was observed several times, thus allowing a greater degree of certainty in registering the data sets. The lightcurve has a synodic period of *P* = 11.542 ± 0.003 h and amplitude *A* = 0.17 ± 0.05 mag.

5421 Ulanova This object was imaged 204 times over 5 nights (2009 November 8, 10, 11; December 5, 12). The lightcurve exhibits a bimodal curve. Despite the relatively faint nature of the target, the scatter on the data points was limited to ± 0.07 mag. The synodic period is *P* = 9.77 ± 0.01 h and *A* = 0.60 ± 0.05 mag.

| Object | Date/Time (UT) | Dec | (″/min) | V |
|---|---|---|---|---|
| 3567 | 2009-10-13.80551 | +24° | 0.43 | 14.5 |
| 5421 | 2009-11-8.75956 | +13° | 0.35 | 15.6 |

Table I. Selected asteroid targets and their initial campaign parameters.

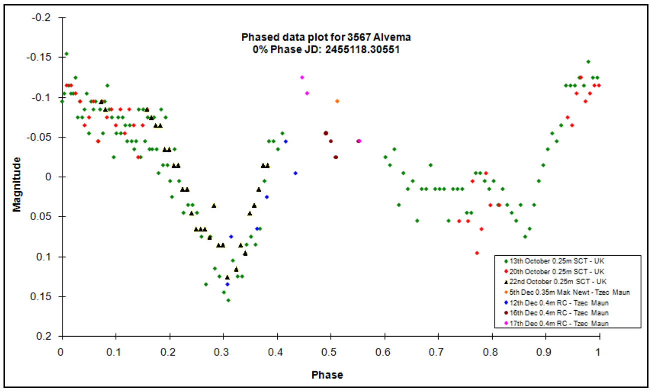

Figure 1. Lightcurve for 3567 Alvema.

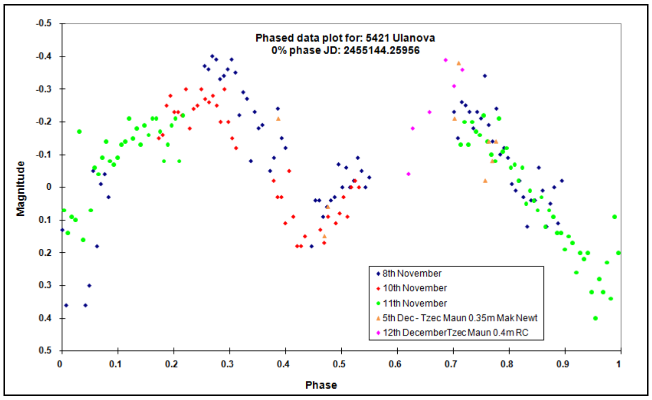

Figure 2. Lightcurve for 5421 Ulanova.

## Acknowledgements

The author thanks the Tzec Maun Foundation for allowing access to their remote telescope facilities based at New Mexico Skies. http://www.tzecmaun.org/.

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# THE ROTATIONAL PERIOD OF 2235 VITTORE

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Lightcurve data of 2235 Vittore were acquired at the Via Capote Observatory in California, USA, and Hunters Hill Observatory in Australia. A rotation period of 32.1 ± 0.01 hrs with an amplitude of 0.21 mag was obtained in this collaborative effort.

Observations at the Via Capote Observatory were made using a Meade LX-200 0.36-m f/10 Schmidt-Cassegrain (SCT). The CCD imager was an Alta U6 with a 1024x1024 array of 24-micron pixels. All observations were made at 1x binning yielding an image scale of 1.44 arcseconds per pixel. All images were dark and flat field corrected. All sessions except 526 were acquired at the Via Capote Observatory. Observations at Hunters Hill Observatory (session 526) were made using Meade LX-200 0.36-m SCT working at f/4. The CCD imager was an SBIG ST-8E with a 1530 x 1020 array of 9-micron pixels operating at -10° C. All observations were taken at a sub-frame of 1148 x 765 pixels at 1x binning yielding an image scale of 1.31 arcseconds per pixel. All images were dark and flat field corrected with no other image enhancements made. Images were measured using *MPO Canopus* (Bdw Publishing). All observations were made using unfiltered differential photometry and the data were light-time corrected. Period analysis was also done with *Canopus*, incorporating the Fourier analysis algorithm developed by Harris (1989).

The project was initially started at Via Capote. After seven observing sessions, a significant uncertainty in the lightcurve period remained. There were several possible candidates in the period spectrum but no dominate candidate was emerging. Because there was evidence the rotation period was rather long, a collaboration request was sent to Hunters Hill for help with this project. The location of the Hunters Hill observatory is very complimentary to that of Via Capote's location in that collaborative image runs on the same target can be effectively extended 10 hours or longer. Nearly one hour of simultaneous observations were made on December 18. This permitted a direct linkage of sorts for the two data sets and improved the period solution significantly. Although there is rather dense coverage of the target for most of phase angles of rotation, some gaps remain and so the period remains less than secure. A plot of the period spectrum for candidate rotation periods is shown below. In this case, collaboration even though consisting of only one session, significantly improved the confidence of the entire project. We could find no previously reported lightcurves for this object.

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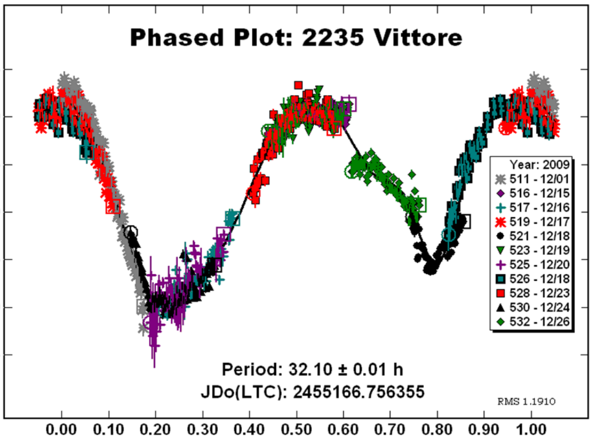

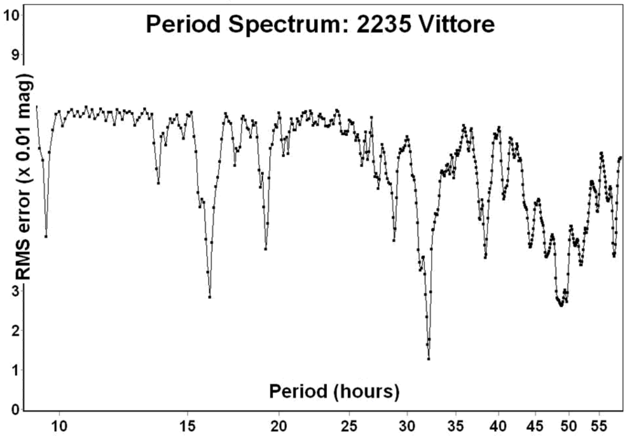

| # Name | Date Range (mm/dd/2009 | Data Points | Phase | $L_{PAB}$ | $B_{PAB}$ | Period (h) | PE (h) | Amp (mag) | AE (mag) |
|---|---|---|---|---|---|---|---|---|---|
| 2235 Vittore | 12/01 - 12/26 | 992 | 10.5 9.2 10.5 | 83 | -20 | 32.1 | 0.01 | 0.21 | 0.03 |

Table I. Observing circumstances and results for 2235 Vittore.

# ASTEROID LIGHTCURVES FROM THE CHIRO OBSERVATORY

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Asteroid lightcurve period and amplitude results obtained at the Chiro Observatory in Western Australia during 2009 June are presented for: 180 Garumna, 1311 Knopfia, 1599 Giomus, 1840 Hus, (6495) 1992 UB1, (16924) 1998 FL61, (43064) 1999 VK114, (43595) 2001 QT101, (51276) 2000 JZ71, (52722) 1998 GK, (54896) 2001 OP70, (74350) 1998 VO54, (77733) 2000 OS73, 79087 Scheidt, and (87228) 2000 OD42

Chiro Observatory is a private observatory owned by Akira Fuji near Yerecion in Western Australia (MPC 320). The main instrument is a 0.30-m f/6 Newtonian. An SBIG STL-1001E CCD was used with this telescope. All images were unfiltered and were reduced with dark frames and sky flats. A 125-mm f/5 refractor with an SBIG ST-8XE CCD and red filter was also used. Images were again reduced with dark frames and sky flats. All images with both CCD's were of 180-seconds duration.

The asteroids were chosen from the Collaborative Asteroid Lightcurve Link home page that is maintained by Brian Warner (CALL, Warner 2010). Where possible, asteroids were chosen that would have other asteroids in the field on at least some nights in an effort to maximize the data. Since, in most cases, these other asteroids were V > 17, the data tended to be noisy. However, the exercise was felt to be worthwhile (doing photometry on an 18th magnitude asteroid with a 0.30-m telescope can be "*interesting*"!) Another factor that needed to be considered was that during June, the opposition point, where most asteroids are at their brightest, coincides with the region of the Milky Way with the highest density of stars, making photometry of a moving object difficult in the extreme! For this reason, asteroids either with high southern declinations or well away from opposition point were chosen. Despite this, some problems with field stars were experienced.

Image analysis was accomplished using differential aperture photometry with *MPO Canopus*. Period analysis was also done in *Canopus*, which implements the FALC algorithm developed by Alan Harris (Harris et al., 1989). Differential magnitudes were calculated using reference stars from the USNO-A 2.0 catalog and the UCAC2 catalog. Results are summarized in the table below, and the lightcurve plots are presented at the end of the paper. The data and curves are presented without additional comment except were circumstances warrant.

180 Garumna. Observations of this asteroid were made on four nights, while it was in the field of the asteroid I was principally studying. Observations in 2004 by the author, R. Roy, D. Starkey, and S. Sposetti enabled R. Behrend (2010) to derive a provisional rotation period of 23.85 h. The latest observations support a period somewhat over 23 hours. Since the observations cover only a small portion of the lightcurve, the period should still be considered only approximate. This asteroid next reaches opposition in 2010 July, when it will be a little brighter than 15th magnitude and at a declination of about –17°, which will make it accessible to observers in both hemispheres. I would be very interested in hearing from other observers who would be willing to contribute to a world-wide campaign during that opposition, with the aim of accurately deriving the rotation period.

1840 Hus. This was another asteroid that was observed only when it was in the same field as another. The results were noisy but indicated an asymmetric lightcurve with a period of 4.78 hours.

(43064) 1999 VK114. This asteroid was observed on only one night as it passed through the field of an asteroid that I was targeting. The lightcurve is very asymmetric and further observations at the next opposition would be very useful.

(43595) 2001 QT101. This asteroid was observed on six nights and the resulting lightcurve indicated a period of just over 22 hours. This is another asteroid that would benefit from international collaboration at the next opposition, which will be in 2010 December. Unfortunately, at the time it will be a 17th magnitude object deep in the Auriga Milky Way, making it an extremely difficult object for photometry.

(52722) 1998 GK. Observations of this asteroid indicated a period of slightly less than half a day. As a result, the entire lightcurve could not be obtained. Although a double-peak lightcurve gives the most satisfactory results, a single peak lightcurve has been included for comparison.

79087 Scheidt. Observations were made on only two nights and indicated a lightcurve with an extremely large amplitude of almost 3 magnitudes and a period of a little less than 10 hours. Although the asteroid was clearly visible in the images, the faintness of the asteroid (18th magnitude) and the very large amplitude make the results more than a little suspicious.

(87228) 2000 OD42. Observations on two nights yielded a reasonably good, though incomplete, lightcurve with a period of just over 18 hours and a large amplitude of about 2 magnitudes.

## Acknowledgments

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

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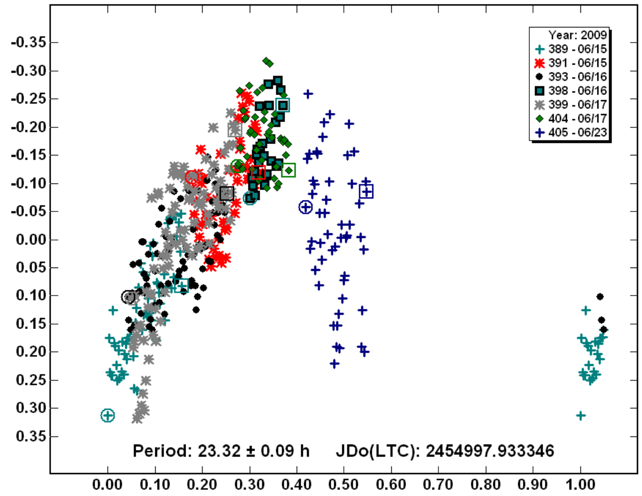
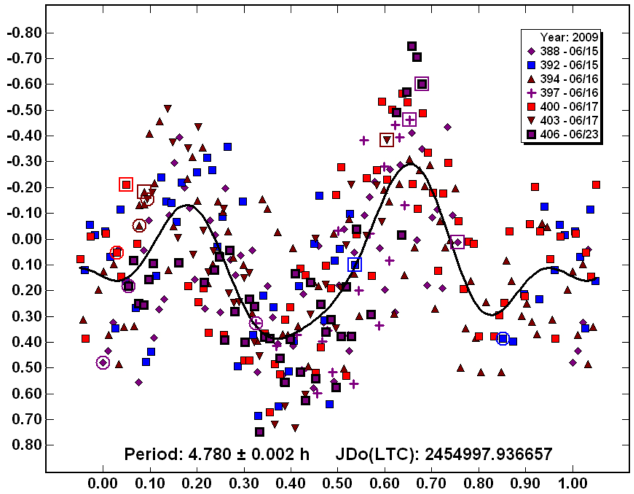
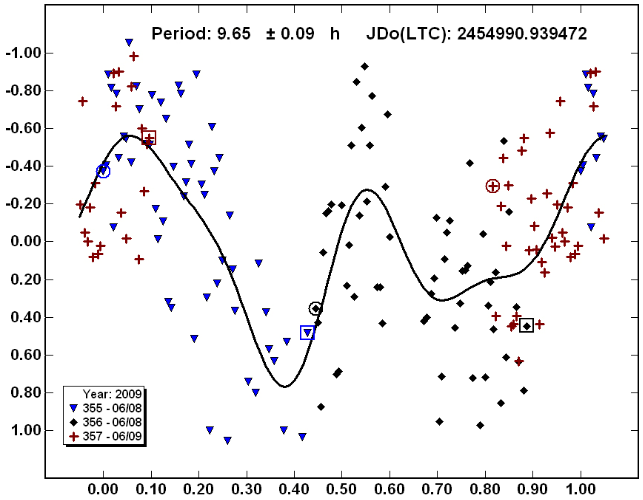


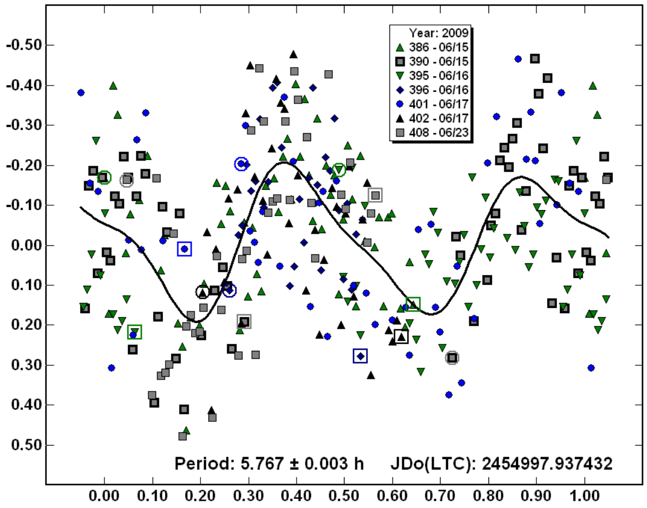
Phased Plot: 180 Garumna



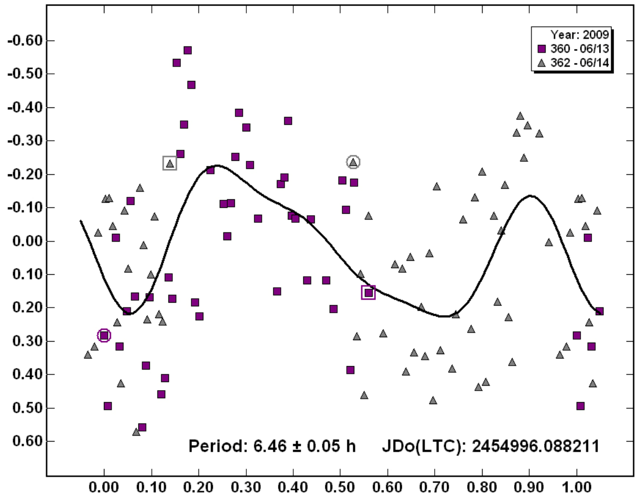
Phased Plot: 1840 Hus



Phased Plot: 1311 Knopfia



Phased Plot: 6495 1992UB1



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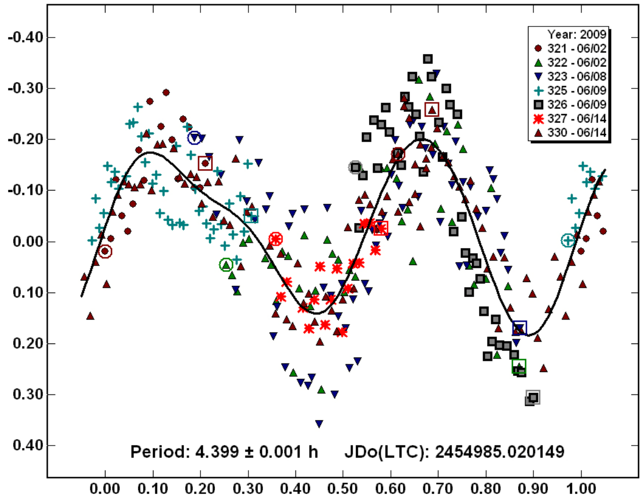

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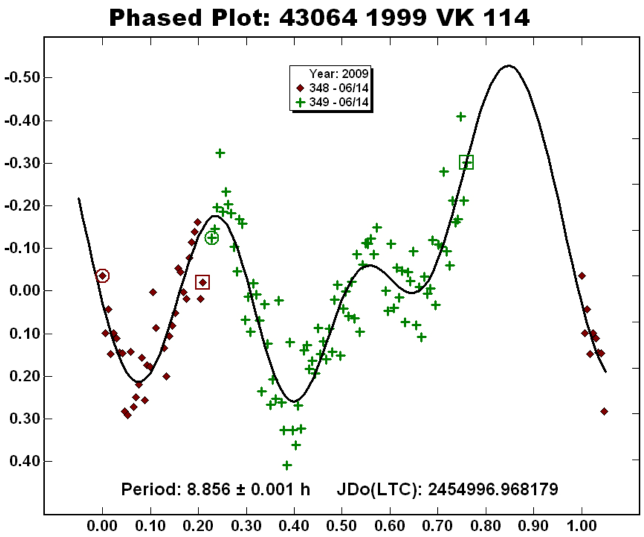
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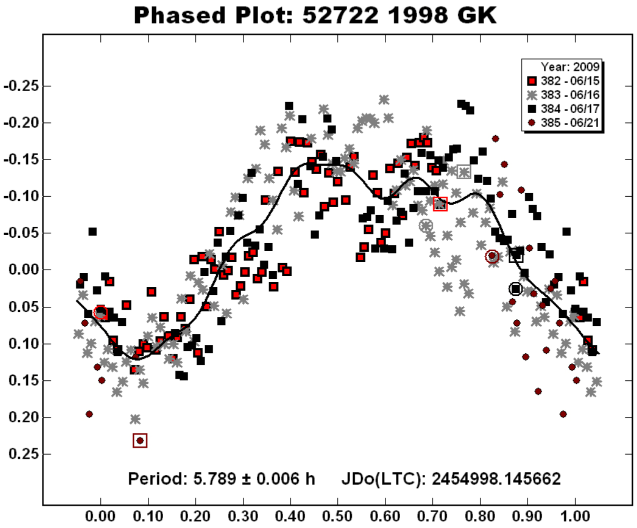
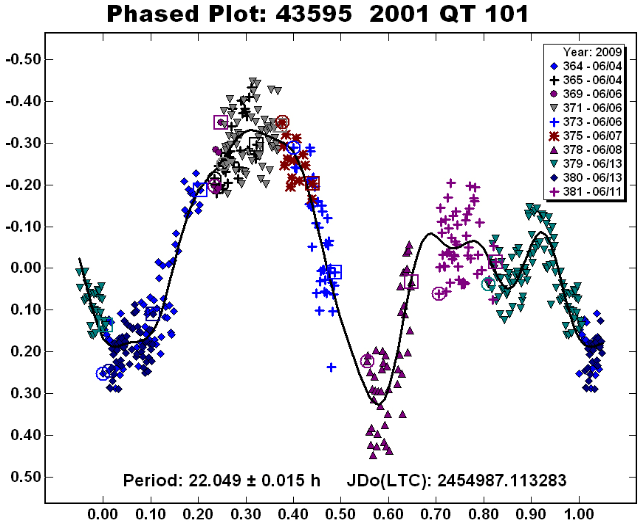

Phased Plot: 52722 1998 GK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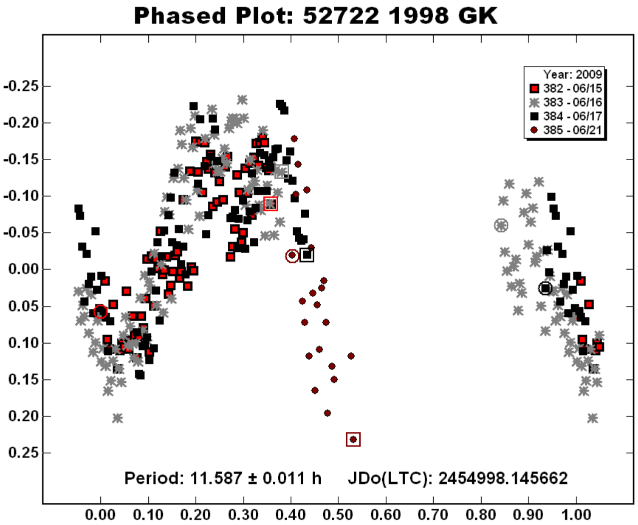
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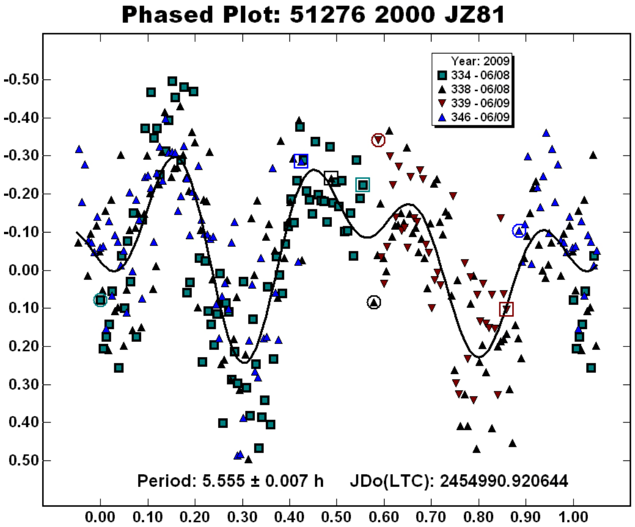
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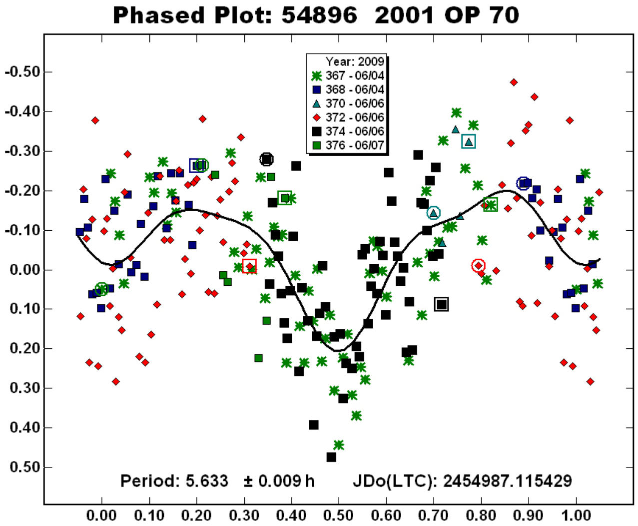
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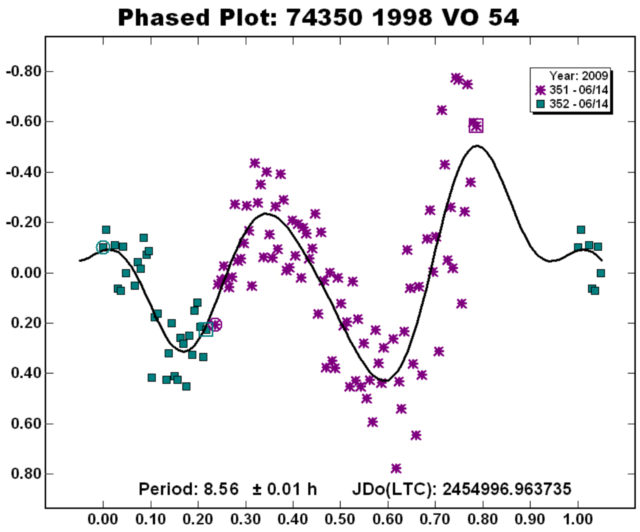

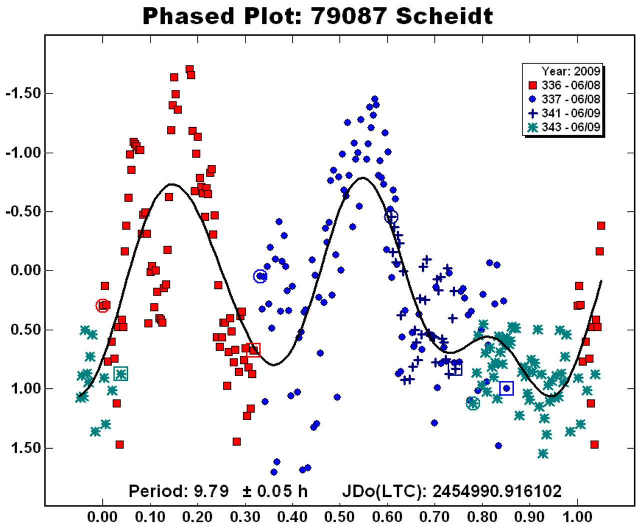

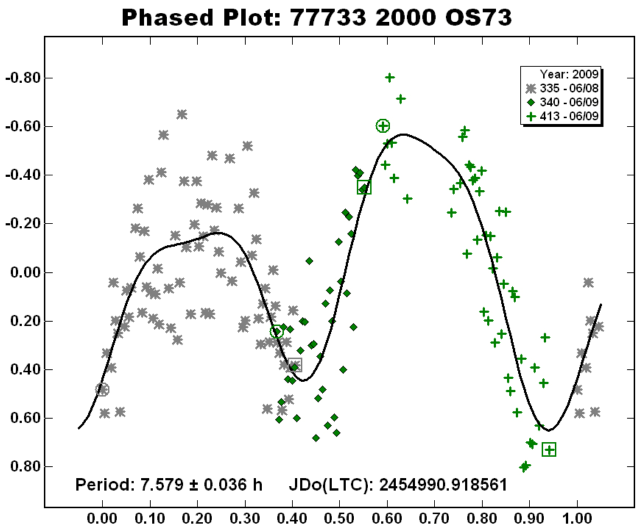

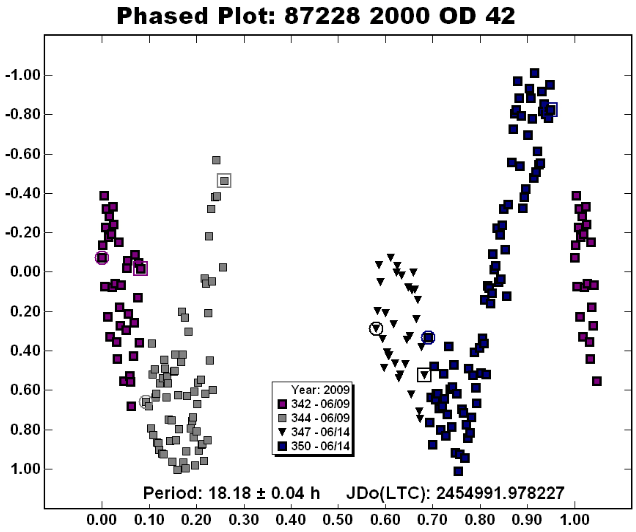

| # | Name | Date Range mm/dd 2009 | Sessions | Per (h) | P.E. (h) | Amp | A.E. |
|---|---|---|---|---|---|---|---|
| 180 | Garumna | 06/15-06/23 | 4 | 23.32 | 0.09 | 0.6 | 0.1 |
| 1311 | Knopfia | 06/08-06/09 | 2 | 9.65 | 0.09 | 1.3 | 0.3 |
| 1599 | Giomus | 06/13-06/14 | 2 | 6.46 | 0.05 | 0.6 | 0.3 |
| 1840 | Hus | 06/15-06/23 | 4 | 4.780 | 0.002 | 1.1 | 0.3 |
| 6495 | 1992 UB1 | 06/15-06/23 | 4 | 5.767 | 0.003 | 0.4 | 0.2 |
| 16924 | 1998 FL61 | 06/02-06/14 | 4 | 4.399 | 0.001 | 0.5 | 0.1 |
| 43064 | 1999 VK114 | 06/14 | 1 | 8.856 | 0.001 | 0.6 | 0.1 |
| 43595 | 2001 QT101 | 06/04-06/11 | 6 | 22.049 | 0.015 | 0.8 | 0.1 |
| 51276 | 2000 JZ71 | 06/08-06/09 | 2 | 5.555 | 0.007 | 0.8 | 0.1 |
| 52722 | 1998 GK | 06/15-06/21 | 4 | 11.587 | 0.011 | 0.4 | 0.1 |
| 54896 | 2001 OP70 | 06/04-06/07 | 3 | 5.633 | 0.009 | 0.6 | 0.2 |
| 74350 | 1998 VO54 | 06/14 | 1 | 8.56 | 0.01 | 1.2 | 0.2 |
| 77733 | 2000 OS73 | 06/08-06/09 | 2 | 7.579 | 0.036 | 1.2 | 0.2 |
| 79087 | Scheidt | 06/08-06/09 | 2 | 9.79 | 0.05 | 2.8 | 0.3 |
| 87228 | 2000 OD42 | 06/08-06/14 | 2 | 18.18 | 0.04 | 2.0 | 0.3 |

# LIGHTCURVES AND PERIODS FOR ASTEROIDS 1001 GAUSSIA, 1060 MAGNOLIA, 1750 ECKERT, 2888 HODGSON, AND 3534 SAX

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(Received: 23 March)

Five asteroids were observed and lightcurves measured at OAVdA from 2009 September through November: 1001 Gaussia, 1060 Magnolia, 1750 Eckert, 2888 Hodgson, and 3534 Sax.

During the latter part of 2009, university student Dimitrij Bonzo and Dr. Albino Carbognani obtained lightcurves for five main-belt asteroids at OAVdA (Carbognani and Calcidese, 2007). The data were used for Dimitrij’s thesis but also to help increase of the number of asteroid rotation periods, which are still few to have a comprehensive statistical picture of the rotational evolution of these bodies (Carbognani, 2010).

The images were captured using a Ritchey-Chretien 0.4-m telescope operating at f/7.7. The CCD camera was an FLI PL-1001E with 1024×1024 pixels, a field of view of 26′×26′, and an image scale of 1.6″/pixel. Exposure times were 180 s with Clear filter, except for 2888 Hodgson for which we used 120-s exposures. We used Warner (2006) as a reference text for observational techniques and the asteroid lightcurve database (LCDB, Warner et al., 2009 April 21 release) to extract periods for those asteroids with previously reported lightcurve parameters.

Asteroids were chosen using the CALL homepage target list Warner (2009a). Due to the limited time available, we searched for asteroids with positive declination and short rotation period in order to catch the whole lightcurve in a small number of nights. A total of nine asteroids were observed in the period, but three of them were rejected because of a long rotation period: 711 Marmulla, 3345 Starkowsky and (88161) 2000 XK18. The remaining one, 433 Eros, was used to calibrate the optical system. We observed only asteroids that had no previously published results for rotational period, or at least an uncertain one. When possible, we tried to do our differential photometry using the same comparison stars for contiguous sessions in order to avoid the challenging problem of calibration among two or more sessions. For this last purpose, the CMC14 catalogue and method of Richard Miles and Roger Dymock (Miles and Dymock, 2009) was used. Comparison stars for differential photometry were chosen with $0.3 < J\text{-}K < 0.7$, i.e. stars of similar color to the Sun.

We used *MPO Canopus* (Warner, 2009b) for period analysis. For the reported lightcurve, we used a 4th order Fourier analysis, starting from a period of 2 h to 10 h, with steps of 0.001 h. Table I show the periods and the amplitudes results.

<u>1001 Gaussia.</u> A total of 115 images were taken in 4 nights. From the data we extracted a rotation period of 9.172 ± 0.002 h and an amplitude of 0.16 mag. Behrend (2009) previously reported a period of 4.08 h with quality U = 1. As seen in the lightcurve, the last session had significantly larger photometric errors. These were due to clouds and poor seeing. We made a photometric calibration for the first and the second session, and another one for the remaining two. There were more than two weeks between the two pairs of sessions, which we couldn’t link to one another because of the opposition effect, which we did not try to correct.

<u>1060 Magnolia.</u> This is the noisiest lightcurve reported here. We observed this asteroid for two nights with bad atmospheric conditions. This fact caused a decrease of the signal-to-noise ratio and, consequently, an increase of the error bars. There was no need to calibrate sessions because of the short rotation period. Analysis of the data found a rotation period of 3.082 ± 0.003 h and an amplitude of 0.16 mag. Wisniewski et al. (1997) reported a period of 2.78 h while Behrend (2009) found a period of 2.9107 h.

<u>1750 Eckert.</u> A total of 120 images were taken in 2 nights. From the data we extracted a rotation period of 4.492 ± 0.001 h and an amplitude of 0.12 mag. This differs considerably with the period of 375 h found by Warner (2010), who reported an amplitude of 0.87 mag and that the asteroid was likely in non-principal axis rotation (“tumbling”).

<u>2888 Hodgson.</u> A total of 147 images were taken in 4 nights. From the data we extracted a rotation period of 4.842 ± 0.001 h and an amplitude of 0.12 mag. Brinsfield (2010) found a period of 6.905 h. As we did for 1001 Gaussia, we made a photometric calibration for the first and the second session, and separate one for the remaining two. We could not link all curves for the same reason already described for Gaussia.

<u>3534 Sax.</u> A total of 224 images were taken in 5 nights. From the data we extracted a rotation period of 6.221 ± 0.001 h and an amplitude of 0.30 mag. No period had been previously reported. This is the best result for our photometry; there was no need to calibrate sessions because of the short rotation period and high precision data points.

| Number | Dates 2009 mm/dd | Phase [deg] | Period [h] | Amp [mag] |
|---|---|---|---|---|
| 1001 | 11/10-24 | 9.4-13.7 | 9.172 ± 0.002 | 0.16 |
| 1060 | 11/10-21 | 5.9-11.5 | 3.082 ± 0.003 | 0.16 |
| 1750 | 11/10-20 | 21.8-22.4 | 4.492 ± 0.001 | 0.12 |
| 2888 | 09/28-10/25 | 2.0-14.7 | 4.842 ± 0.001 | 0.12 |
| 3534 | 10/26-11/11 | 9.7-2.1 | 6.221 ± 0.001 | 0.30 |

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

## Acknowledgments

I would like to thank my teacher A. Carbognani for helping me in doing this work, my university teacher, P. A. Grassi, the OAVdA staff, Director E. Bertolini for giving me this opportunity, and my family for always having supported me in everything. Research on asteroids at OAVdA is funded with a European Social Fund grant from the Regional Government of the Regione Autonoma della Valle d’Aosta (Italy).

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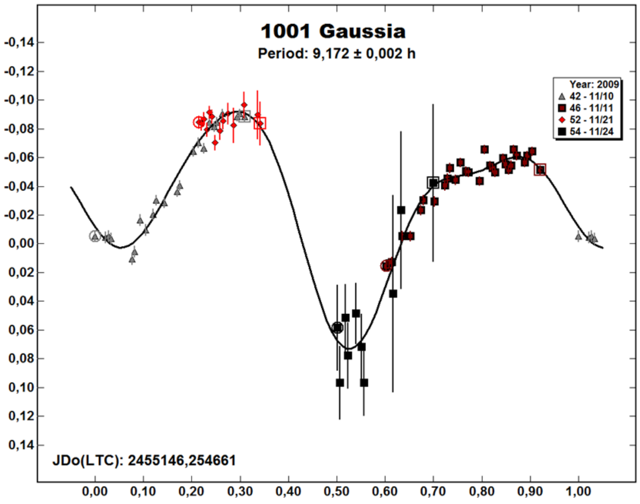

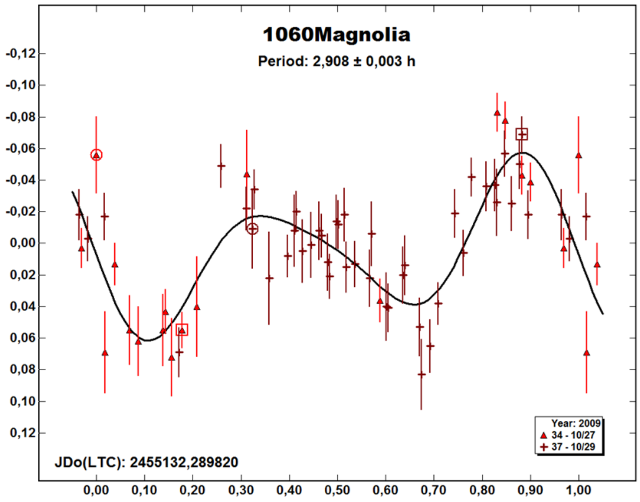

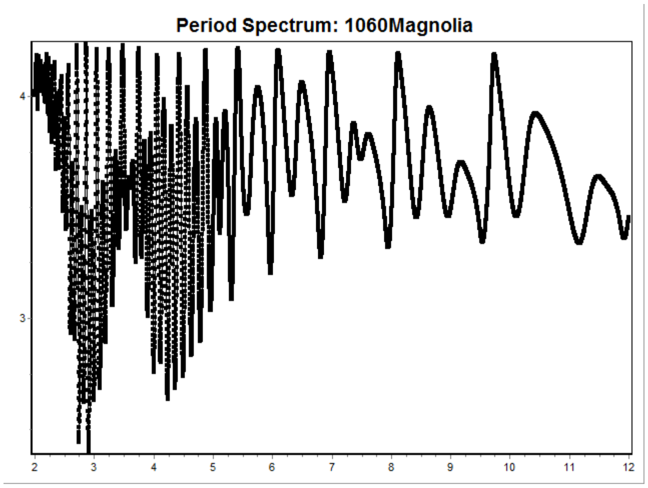

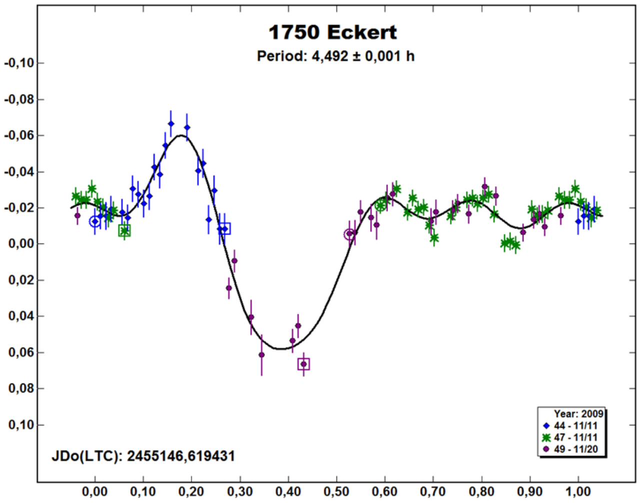

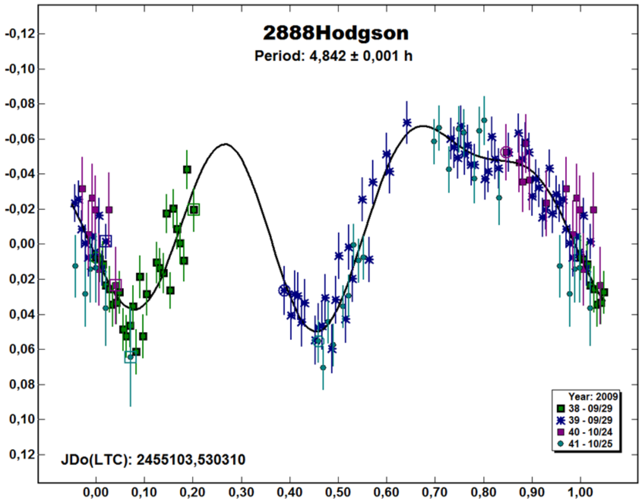

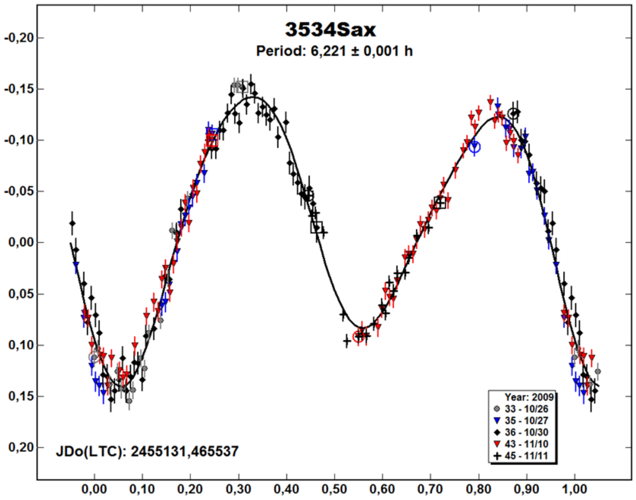

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# PHOTOMETRIC OBSERVATIONS OF THE NEAR-EARTH ASTEROIDS 1999 AP10, 2000 TO64, 2000 UJ1, 2000 XK44, 2001 MZ7, 2003 QO104, 2005 RQ6, 2005 WJ56 AND 2009 UN3

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The near-Earth asteroids 1999 AP10, 2000 TO64, 2000 UJ1, 2000 XK44, 2001 MZ7, 2003 QO104, 2005 RQ6, 2005 WJ56 and 2009 UN3 were observed by the authors between 2008 January and 2010 February at Salvador (Bahia, Brazil), Mayhill (New Mexico, USA) and Moorook (South Australia, Australia) to determine their Johnson-Cousins BVRI colors and from those, provide an estimate of the Tholen taxonomic classification. From our colors, we found that 1999 AP10, 2000 TO64, 2000 UJ1, 2000 XK44 and 2003 QO104 are probably S-complex members. We reanalysed our previous observations of 2005 WJ56 and confirmed a classification as an X type. The latter results agree with the classifications made by other research groups. We propose that 2001 MZ7 is a G type from its presented colors and G parameter. 2005 RQ6 and 2009 UN3 have colors more similar to Q-types.

The near-Earth asteroids 1999 AP10, 2000 TO64, 2000 UJ1, 2000 XK44, 2001 MZ7, 2003 QO104, 2005 RQ6, 2005 WJ56 and 2009 UN3 were observed between 2008 January and 2010 February at Salvador (Bahia, Brazil), Mayhill (New Mexico, USA) and Moorook (South Australia, Australia). The characteristics of the telescopes used and observation sites are shown in Table I. Our goal was to estimate, if possible, the B-V, V-R and R-I colour indexes, H and G parameters and from the asteroid´s colors doing an estimative of the Tholen taxonomic classification.

All science images obtained in Salvador, Mayhill and Moorook were corrected with bias, dark, and dome or sky flat-field frames. Photometric calibration was done using 2MASS stars in the asteroid's field. The 2MASS J-K field star color index were converted to the equivalent V magnitude and B-V, V-R and R-I index of the Johnson-Cousins system using the transformation equations from Warner (2007) and Gary (2008). The color transformation coefficient between the instrumental and Johnson-Cousins photometric system were calculated using definitions by Gary (2006) in every observation session using no less than 10 stars in the asteroid´s field. Only stars with near-solar colors were used to calculate the asteroid color index or obtain their apparent magnitudes. To improve the SNR of the asteroids and comparison stars, we summed images using the IRIS V. 5.52 program.

The taxonomic classification method used in this work is based in the use of two-color diagrams involve the color indices of Tholen classes and the object as used by Dandy et al (2003). Our color index estimates and Tholen taxonomic classifications are summarized in Table II. For an ambiguity in the classification, we list first the type with better color compatibility with the mean Tholen class. This color compatibility was determined using the L1 norm, which was used due to its robustness.

1999 AP10. 1999 AP10 was classified as an S-complex member (L) in the SMASS II taxonomic system using visible long-slit spectra (Hicks and Lawrence 2009). We observed this object in Mayhill in 2009 September 27.23 UT ($\alpha$=26.2$^0$), obtained 16 images of 60s of exposure in B, V, R and I filters. We found B-V=0.859±0.002, V-R=0.459±0.001 and R-I=0.395±0.002, matching the S-type.

2000 TO64. 2000 TO64 was classified as S-complex member (Sq) in the SMASS II taxonomic system using visible long-slit spectra (Hicks and Lawrence 2009). We observed this object at Mayhill in 2009 November 07.11 UT ($\alpha$=56.4$^0$). We obtained 12 images of 60s of exposure in V, R and I filters. We found V-R=0.485±0.003 and R-I=0.379±0.03. Our colors match the S-type.

2000 UJ1. 2000 UJ1 was classified as S-complex member (S) in the SMASS II taxonomic system using visible long-slit spectra (Hicks and Lawrence 2009). We observed this object in Mayhill in 2009 November 06.12 UT ($\alpha$=56.4$^0$), obtained 12 images of 60s of exposure in V, R and I filters. We found V-R=0.474±0.002 and R-I=0.381±0.005. Our colors match the S-type.

2000 XK44. 2000 XK44 was classified as an S-complex member (S) in the SMASS II taxonomic system using visible long-slit spectra (Hicks and Lawrence 2009) and by BVRI colors (Hicks et al. 2010). We observed this object at Mayhill in 2009 November 05.29 UT ($\alpha$=15.7$^0$). We obtained 16 images of 60s of exposure in B, V , R and I filters. We found B-V=0.87±0.03, V-R=0.481±0.006 and R-I= 0.27±0.01. Our colors matched an RS-type (Fig.1).

2001 MZ7. 2000 MZ7 was classified as X-complex member in the SMASS II taxonomic system using near-infrared spectra (Lazzarin et al., 2005). We observed this object at Mayhill and Moorook (G6) in 2010 January 12.33; 16.33; 21.64 and 24.62

UT, obtained 64 images of 60s of exposure in B, V , R and I filters. From our data, we obtained mean colors B-V=0.74±0.02, V-R=0.37±0.02 and R-I= 0.45±0.02. Using A. Harris' FAZ routine within the Canopus program to determine asteroid´s H-G system parameters (Bowell et al. 1989), based on our V apparent magnitudes at various phase angles (8.9 to 20.4 degrees), we found $H_V$ = 15.0±0.1 using G=0.15. When both values are allowed to "float", the results are $H_V$ = 14.93±0.06 and G=0.12±0.06 (fig.2). Both H estimates are consistent with a value of $H$ = 14.8±0.8 reported in the JPL Small-Body Database Browser. Our mean colors and G value (see Warner, Harris and Pravec., 2009) don´t agree with a X-complex member classification for this object. We propose a new classification as a Tholen´s C-complex member (GC) and, with more color compatibility, a G type, and we also recommend a search for hydration bands in the visible (≈0.7μm) and NIR (≈3μm). (See Rivkin et al. 2001.)

<u>2003 QO104.</u> 2003 QO104 was classified as S type by M. D. Hicks (see Benner, 2009). This object has a synodic rotation period of 114.4±0.1h and lightcurve amplitude of 1.60±0.04 mag (Warner et al. 2009). We observed this object at Salvador in 2009 June 19.99 UT ($\alpha$=70.1$^0$) and obtained 24 images of 40 and 60s of exposure in B, V and R filters. We found B-V=0.88±0.02 and V-R=0.45±0.02. Our colors agree with a S or R Tholen type.

<u>2005 RQ6.</u> We observed this object at Mayhill in 2009 November 06.29 UT ($\alpha$=12.8$^0$), and obtained 12 images of 180s of exposure in V, R and I filters. We found V-R=0.423±0.005 and R-I=0.33±0.02. Our colors match consistently with a Q Tholen type. Using our data, we found apparent magnitude V.=15.53±0.02 at 07:07 UT. This value has excellent agreement with the Minor Planet Center (MPC) ephemerides value with <1% error. Using the H-G system and our V apparent magnitude, we estimate a $H_V$ value for 2005 RQ6. Assuming G=0.2±0.1 (Warner, Harris and Pravec 2009), this yields $H_V$=19.22±0.05. This H estimate is consistent with a value of $H$ = 18.9±0.5 reported in the JPL Small-Body Database Browser. As the mean reduced lightcurve amplitude of an analysed NEA sample is 0.29 mag. (Binzel et al., 2001) and that our $H_V$ isn't a mean value over a whole rotational cycle, we can conclude that our absolute magnitude estimate supports the 2005 RQ6´s JPL Small-Body Database´s H value.

<u>2005 WJ56.</u> 2005 WJ56 was classified as a X ($X_K$) type by M. D. Hicks (Benner 2008; Somers et al. 2008) and after as E type by M. D. Hicks and V. Reddy (see Benner et al. 2009) in the context of X type complex (Clark et al., 2004). In our previous work (Betzler et al., 2008), we classified this object as a P type based on its high visible spectral slope and our estimate of H absolute magnitude. In our data processing, we used b and r USNO A2 magnitudes to obtain the Johnson-Cousins B-V, V-R and R-I field star and asteroid colors. However, this b and r magnitude has a typical error of 0.1 mag and with the use of conversion equations to obtain the stars´s colors and magnitudes, high random and systematic errors were propagated in our asteroid color indices. Therefore we reanalyze our data obtained in Salvador on 2008 January 08.02 UT ($\alpha$=26.1$^0$). We found B-V=0.698±0.001, V-R=0.428±0.001 and R-I=0.407±0.001. Our colors match with the X-type.

<u>2009 UN3.</u> 2009 UN3 has a synodic rotation period of 4.1h and 0.4 mag. of lightcurve amplitude, reported by Polling et al. and classified as a S type by Hicks, Barajas and Shitanishi (see Benner., 2010). It was observed in Moorook (G9), in 2010 February 05.55 ($\alpha$=73.5$^0$), and 06.58 UT ($\alpha$=68.3$^0$). We obtained 12 images in B and V filters at February 05th and 16 images in B,V, R and I filters in the second observation session. All images were obtained with 15s of exposure due to the fast angular movement of this object (>20"/min) in order to avoid excessive trailing. In our first observational session, we obtained V=14.47±0.03 and B-V=0.771±0.009. On 2010 Feb 06, we obtained V=14.12±0.02, B-V=0.771±0.005, V-R=0.47±0.02 and R-I=0.266±0.005. The object´s colors in the second observational session suggest that the object may be a QR-type, slightly favoring a Q type. Using the H-G system and V apparent magnitudes, we found a mean $H_V$ and diameter, respectively, equal to 18.6±0.1 and 570±40 m. In order to obtain these estimates, we used mean G and albedo of intermediary taxonomic classes as defined by Warner, Harris and Pravec, (2009). Our measured 2009 UN3 colors, absolute magnitude and diameter agree with Hicks et al (2010b) estimates.

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| Site | Telescope | CCD Detector | Filters |
|---|---|---|---|
| Salvador | 0.30m Meade LX200 f/3.3 (with focal reductor) | SBIG ST-7XME | Custom Scientific BVRI |
| Mayhill | 0.30m f/11.9 Takahashi Mewlon (GRAS G1) | FLI IMG1024 DM Dream Machine | Optec BVRI |
| Moorook | RCOS 0.41m f/8.4.(GRAS G6) | SBIG STL-1001E | RGB |
| Moorook | RCOS 0.32m f/6.3 (GRAS G9) | SBIG ST-8 NABG | BVRI |

Table I. Summary of Instrumentation.

| **Object** | **B-V** | **V-R** | **R-I** | **Classification (Tholen)** |
|---|---|---|---|---|
| 1999 AP10 | 0.859±0.002 | 0.459±0.001 | 0.395±0.002 | S |
| 2000 TO64 | Not Measured | 0.485±0.003 | 0.379±0.03 | S |
| 2000 UJ1 | Not Measured | 0.474±0.002 | 0.381±0.005 | S |
| 2000 XK44 | 0.87±0.03 | 0.481±0.006 | 0.27±0.01 | R |
| 2001 MZ7 | 0.74±0.02 | 0.37±0.02 | 0.45±0.02 | G |
| 2003 QO104 | 0.88±0.02 | 0.45±0.02 | Not Measured | S or R |
| 2005 RQ6 | Not Measured | 0.423±0.005 | 0.33±0.02 | Q |
| 2005 WJ56 | 0.698±0.001 | 0.428±0.001 | 0.407±0.001 | X |
| 2009 UN3 | 0.771±0.005 | 0.47±0.02 | 0.266±0.005 | Q |

Table II. Summary of this work’s NEA´s color indices and likely taxonomic classifications.

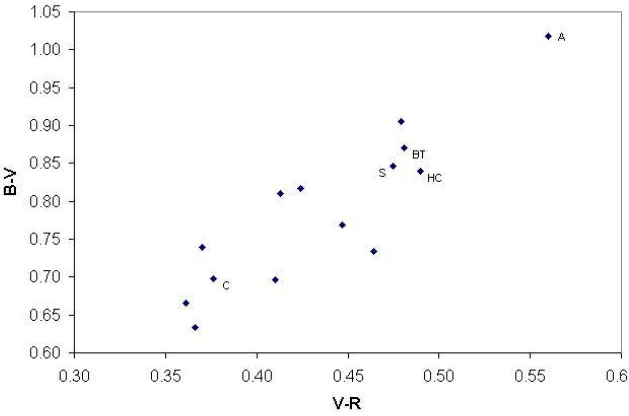

Figure 1. Plot of the B-V versus V-R of typical Tholen taxonomic types colors and the colors obtained in this work (BT) and by Hicks et al. (2010) (HC) for 2000 XK44. “S”, “A” and “C” are, respectively, the S, A and C types mean colors, with typical uncertainties of +/- 0.03 mag.

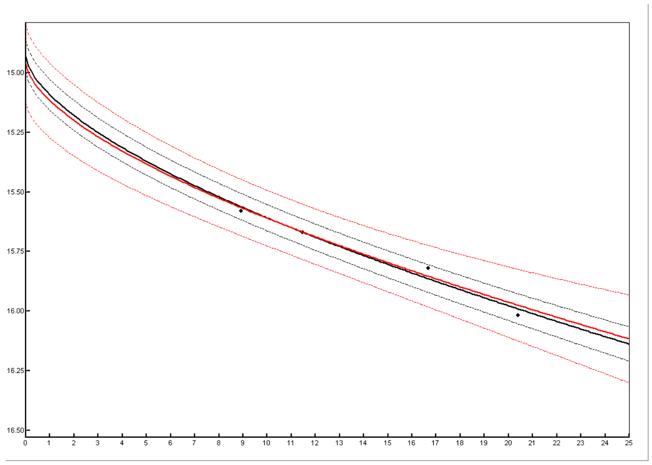

Figure 2. Plot of the reduced magnitude of 2001 MZ7 versus the phase angle. The solid black line corresponds to a curve with G=0.12±0.06 and the red line to G=0.2(0.15)±0.2. The reduced magnitudes have ~0.01 mag. of error.

# A NEW INVESTIGATION OF THE ROTATION PERIOD AND SIZE OF 71 NIOBE

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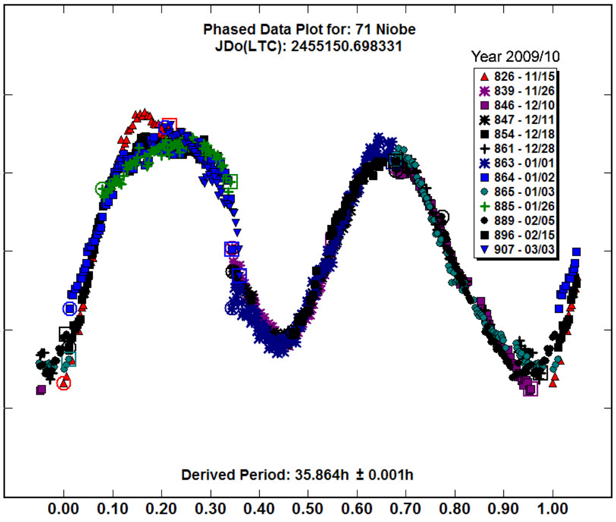
New lightcurves of 71 Niobe show a synodic rotation period of 35.864 ± 0.001 hours, amplitude 0.15 ± 0.02 magnitudes. Six isolated occultation chords have lengths 13 – 76 kilometers. This makes a size significantly larger than the IRAS value of 87 km, and a rotation period near 72 hours allowed by the photometric data, extremely unlikely.

Among the lower numbered asteroids 71 Niobe has been one of the most difficult to obtain a secure rotation period because it is both long and highly Earth commensurate. Early investigations were hampered by a shortage of telescope time and produced only sparse data sets. These earlier period determinations include: Lustig and Dvorak (1975), 11.21 hours; Barucci and Fulchignoni (1984) were unable to find a period; Harris and Young (1989), 14.38 hours; Piironen et. al. (1998), 14.34 hours. Warner et. al. (2006) produced the first dense lightcurve which showed a period of 35.6 hours, amplitude 0.22 magnitudes. Sada and Warner (2007) extended the interval of the 2006 observations from two weeks to two months and improved the period to 35.81 hours. Shepard et. al. (2008) published radar observations of 71 Niobe from Arecibo in the same time frame as the lightcurves by Sada and Warner (2007). Assuming P = 35.8 h, the observed 2380 MHz radar echo Doppler bandwidth of B = 75 ± 15 Hz indicates a maximum dimension (diameter along the major axis) of 97 ± 20 km if observed at an equatorial aspect (larger if observed at mid- or high latitudes). This is consistent with the IRAS survey diameter of 87.3 ± 1.7 km by Tedesco et. al. (1989). However, if the rotation period is doubled to the alternate 71.7 h, the diameter must double to 200 km (M. Shepard, personal communication).

A maximum elongation 2009 Dec. 31 at declination +44 degrees provided an opportunity for a new investigation at the Organ Mesa Observatory. Equipment consists of a 35 cm Meade LX200 GPS S-C, SBIG STL-1001E CCD, 60 s unguided exposures through a R filter, differential photometry only. Lightcurve analysis is by *MPO Canopus*. Because of the large number of data points they are binned for the lightcurve in sets of 5 with a maximum interval of 10 minutes between sets. With an expected period exactly 3/2 that of Earth, lightcurves obtained at intervals of 3 days or any multiple thereof should be identical except for variations caused by changing phase angle. The combination of long nights near the winter solstice and far northerly declination provided an opportunity to obtain single night lightcurves of nearly 12 hours duration at opposition. Except for very small gaps between the three segments, near 100% phase coverage of the lightcurve could be obtained on three consecutive nights from a single observatory. Sessions accomplishing this goal were performed 2010 Jan. 1, 2, 3, although observations were started 2009 Nov. 15 and continued until 2010 Mar. 3, on a total of 13 nights, to refine the period to 35.864 ± 0.001 hours, amplitude 0.15 ± 0.02 magnitudes.

A period near 71.73 hours, with likely 4 maxima and minima per cycle, is also allowed by the photometric data, with half of the lightcurve unobservable from any single location. Doubling the rotation period also doubles the diameter obtained from the radar observations by Shepard et. al. (2008) to near 200 km, a severe conflict with the diameter as found by IRAS. Furthermore, 6 stellar occultations by 71 Niobe (asteroid occultation website 2010) have been observed in recent years. For five of these only a single chord was observed: 13 km 2004 Nov. 2; 54 km 2005 Feb. 10; 72 km 2005 Nov. 10; 76 km 2007 May 15; 69 km 2010 Jan. 19. For the sixth, 2009 Aug. 24, three positive chords of lengths 62 km, 21 km, 15 km, respectively, with 27 km across the occultation path between the largest and smallest occultation chords, were observed. These constrain the size to not much larger than 76 km diameter. For a spherical body in equatorial aspect, a chord length of ½ diameter occurs at 60 degrees N or S latitude. This is in cross section r sin 60° = 0.866 r from the equator, where r is the radius. For a chord at random distance from the equator the probability of a chord length < r = ½ diameter is 0.134. This probability also holds for an ellipsoidal body, and approximately for a real asteroid so long as the shape is not bizarre. Nothing in any of the published lightcurves suggests a bizarre shape on a global scale. Of the 6 occultation events, all have chord length ≤ 76 km. The probability of a diameter 152 km is therefore $0.134^6 = 5.79 \times 10^{-6}$, and of a larger diameter is even smaller. This is strong evidence for a diameter not much larger than 76 km, and effectively rules out a 194 km diameter and from the radar measured bandwidth a rotation period near 72 hours.



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# ASTEROID LIGHTCURVE ANALYSIS AT THE OAKLEY SOUTHERN SKY OBSERVATORY: 2009 AUGUST-NOVEMBER

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(Received: 20 February)

Photometric data for 24 asteroids were collected over 22 nights of observing during 2009 August through November at the Oakley Southern Sky Observatory. The asteroids were: 1654 Bojeva, 2013 Tucapel, 2216 Kerch, 2219 Mannucci, 3045 Alois, 3422 Reid, 3819 Robinson, 5832 Martaprincipe, 5914 Kathywhaler, 6066 Hendricks, 6734 Benzenberg, (7774) 1992 UU2, (9199) 1993 FO1, 10094 Eijikato, 11064 Dogen, 13123 Tyson, (13709) 1998 QE13, (14162) 1998 TV1, (19732) 1999 XF165, (20762) 2000 EE6, (27181) 1999 CX1, (29251) 1992 UH4, (29742) 1999 BQ12, and (55760) 1992 BL1.

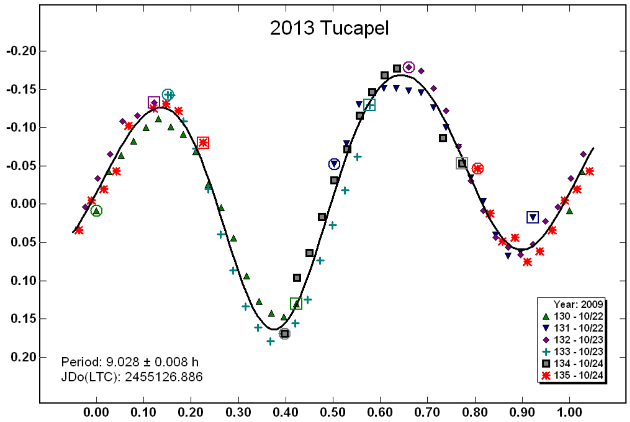
Twenty-four asteroids were observed from the Oakley Southern Sky Observatory in New South Wales, Australia, near Coonabarabran on the nights of 2009 August 10-15, 17-18, and 26-27; October 7-9 and 20-24; and November 9-11, and 14. We were able to find lightcurves for 15 asteroids, none of which had previously published periods. We were unable to determine a period from our data on the remaining 9 asteroids.

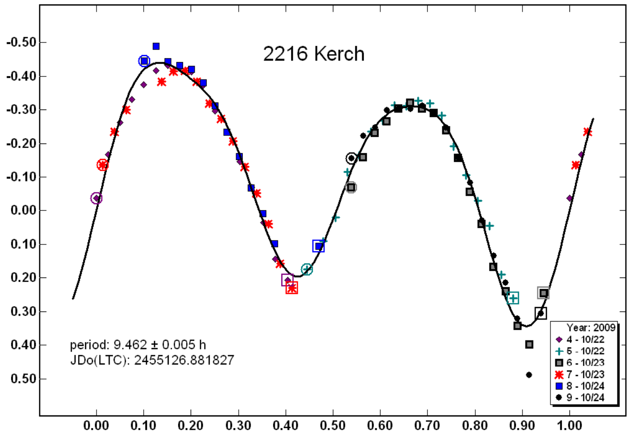
Asteroids were selected based on their position in the sky about one hour after sunset. Throughout the selection, asteroids without previously published periods were given higher priority than asteroids with known periods. For the 22 nights of observing, a 0.5-m f/8.4 Ritchey-Chretien optical tube assembly mounted on a Paramount ME was used with a Santa Barbara Instrument Group STL-1001E CCD camera and a clear filter. The image scale was 1.2 arcseconds per pixel. Exposure times varied between 90 and 240 seconds. Calibration of the images was done using master twilight flats, darks, and bias frames. All calibration frames were created using *CCDSoft*. *MPO Canopus* was used to measure the processed images.

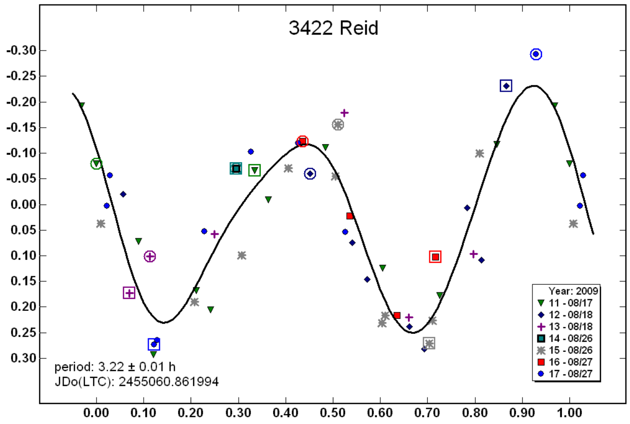
As far as we are aware, these are the first reported lightcurves for those 15 asteroids where we found a period and amplitude. No repeatable pattern was found for 1654 Bojeva, 2219 Mannucci, 3045 Alois, 3819 Robinson, 5832 Martaprincipe, 5914 Kathywhaler, 6734 Benzenberg, (13709) 1998 QE13, or (14162) 1998 TV1. Our data for these asteroids were so noisy that we feel comfortable publishing only the amplitudes. Results from the asteroids are listed in the table below.

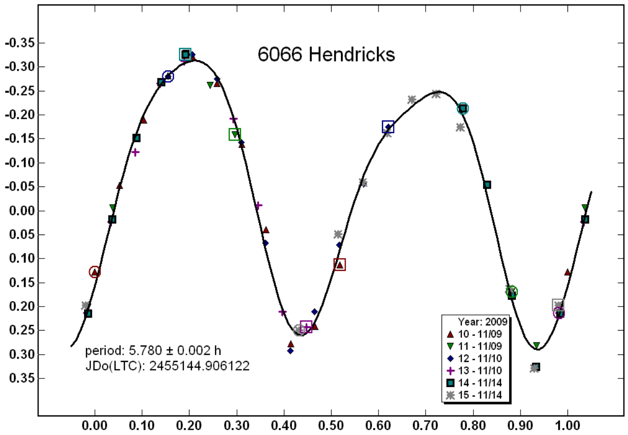
## Acknowledgement

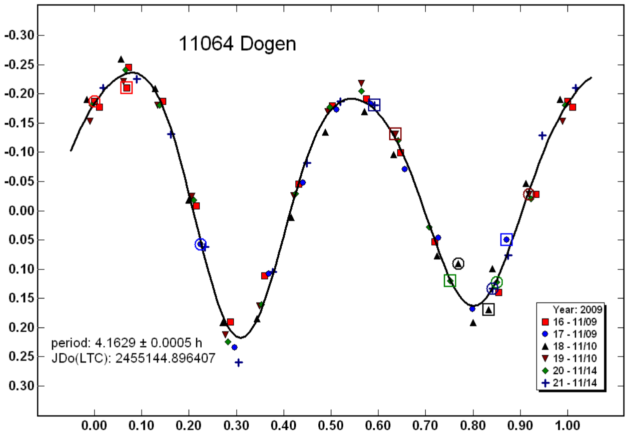
Construction of the Oakley Southern Sky Observatory was funded by a grant from the Oakley Foundation and by a generous donation made by Niles Noblitt.

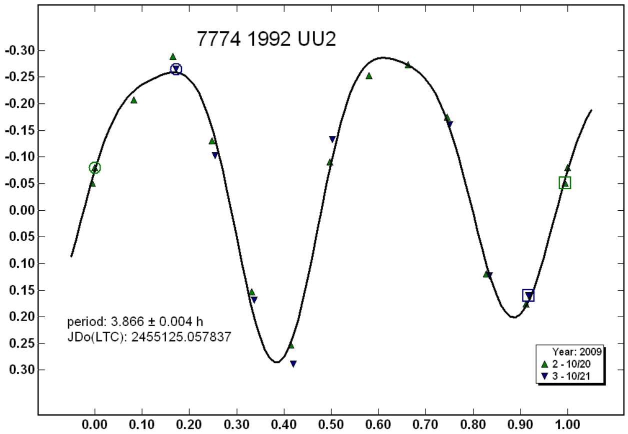


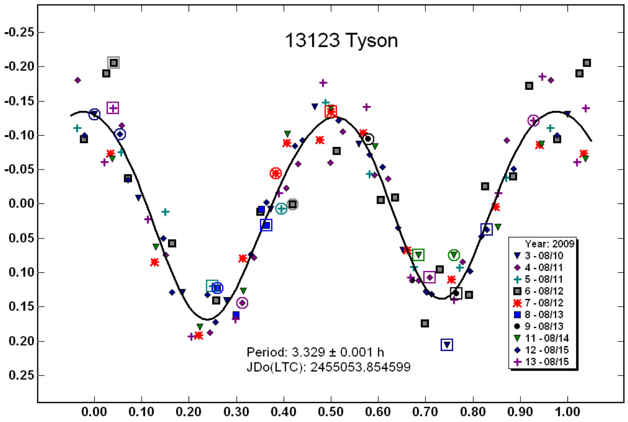


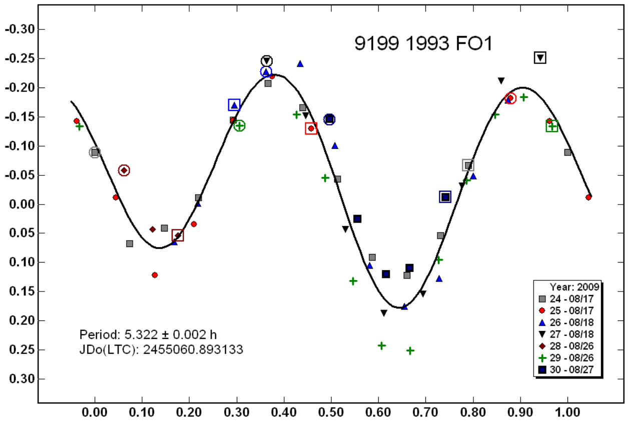


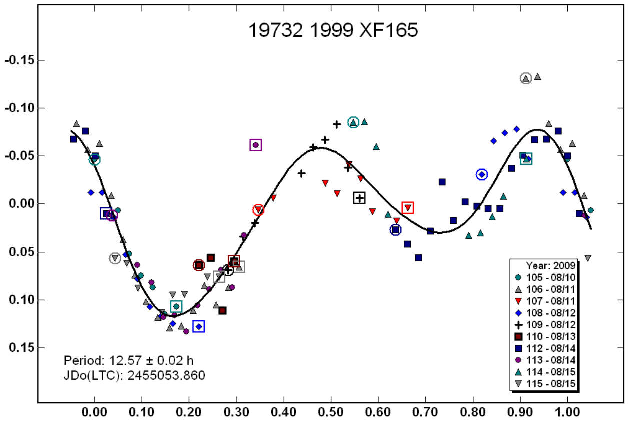

6066 Hendricks
period: 5.780 ± 0.002 h
JDo(LTC): 2455144.906122
Year: 2009
10 - 11/09
11 - 11/09
12 - 11/10
13 - 11/10
14 - 11/14
15 - 11/14
-0.35 -0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

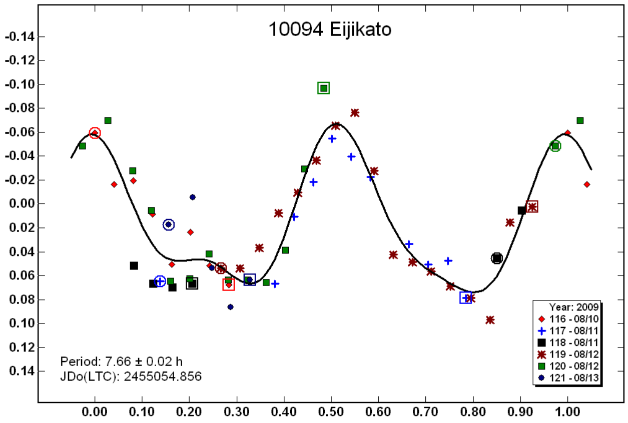

11064 Dogen
period: 4.1629 ± 0.0005 h
JDo(LTC): 2455144.896407
Year: 2009
16 - 11/09
17 - 11/09
18 - 11/10
19 - 11/10
20 - 11/14
21 - 11/14
-0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

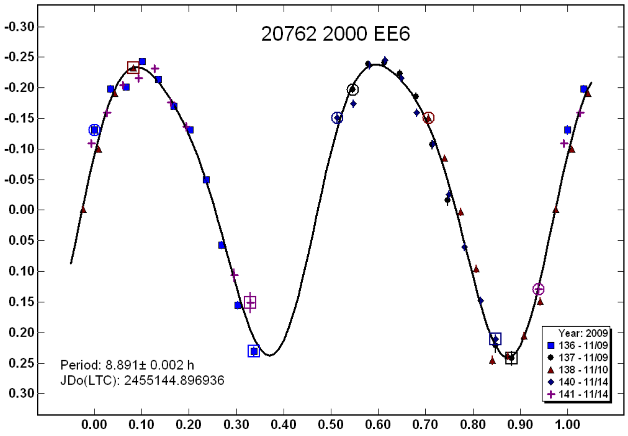

7774 1992 UU2
period: 3.866 ± 0.004 h
JDo(LTC): 2455125.057837
Year: 2009
2 - 10/20
3 - 10/21
-0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

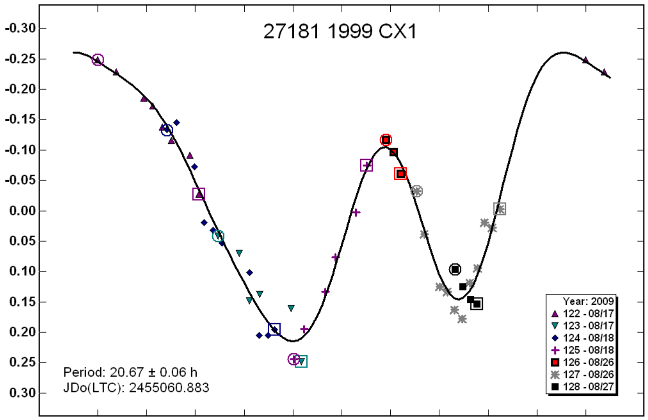

13123 Tyson
Period: 3.329 ± 0.001 h
JDo(LTC): 2455053.854599
Year: 2009
3 - 08/10
4 - 08/11
5 - 08/11
6 - 08/12
7 - 08/12
8 - 08/13
9 - 08/13
11 - 08/14
12 - 08/15
13 - 08/15
-0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

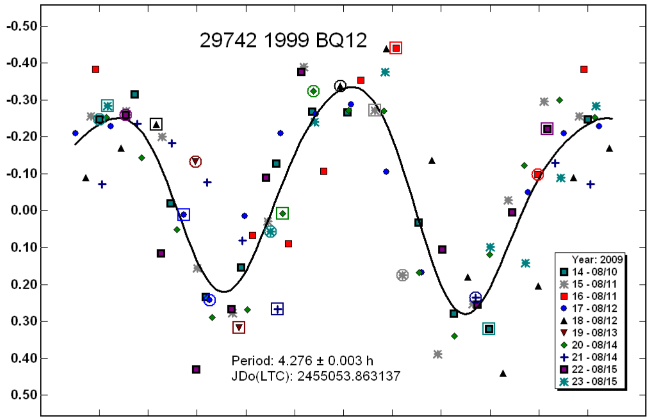

9199 1993 FO1
Period: 5.322 ± 0.002 h
JDo(LTC): 2455060.893133
Year: 2009
24 - 08/17
25 - 08/17
26 - 08/18
27 - 08/18
28 - 08/26
29 - 08/26
30 - 08/27
-0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

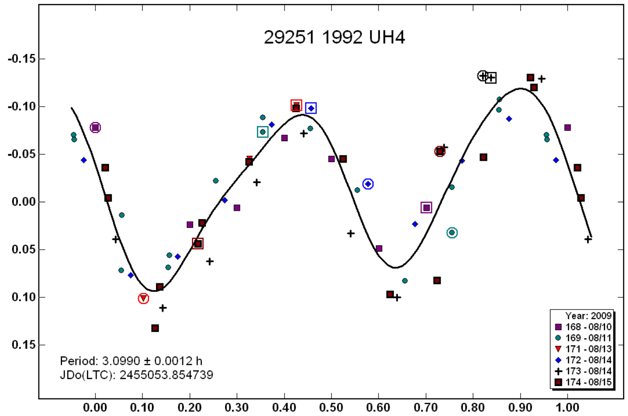

19732 1999 XF165
Period: 12.57 ± 0.02 h
JDo(LTC): 2455053.860
Year: 2009
105 - 08/10
106 - 08/11
107 - 08/11
108 - 08/12
109 - 08/12
110 - 08/13
112 - 08/14
113 - 08/14
114 - 08/15
115 - 08/15
-0.15 -0.10 -0.05 0.00 0.05 0.10 0.15
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

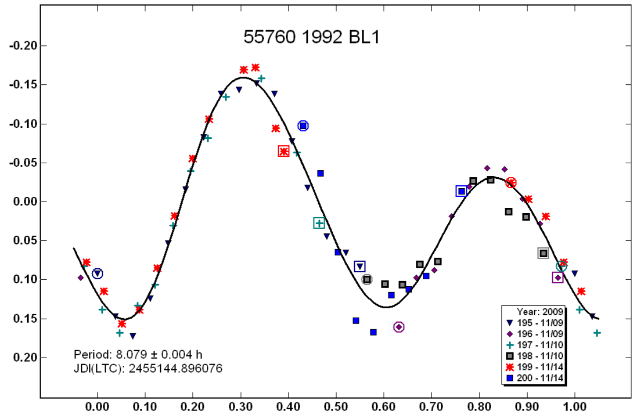

10094 Eijikato
Period: 7.66 ± 0.02 h
JDo(LTC): 2455054.856
Year: 2009
116 - 08/10
117 - 08/11
118 - 08/11
119 - 08/12
120 - 08/12
121 - 08/13
-0.14 -0.12 -0.10 -0.08 -0.06 -0.04 -0.02 0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


20762 2000 EE6
Period: 8.891± 0.002 h
JDo(LTC): 2455144.896936
Year: 2009
136 - 11/09
137 - 11/09
138 - 11/10
140 - 11/14
141 - 11/14
-0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00









| Number | Name | Dates mm/dd 2009 | Data Points | Period | P. E. (h) | Amp (mag) | A. E. (mag) |
|---|---|---|---|---|---|---|---|
| 1654 | Bojeva | 8/17-18, 8/26-27 | 51 | | | 0.10 | 0.02 |
| 2013 | Tucapel | 10/22-24 | 97 | 9.028 | 0.008 | 0.34 | 0.04 |
| 2216 | Kerch | 10/22-24 | 97 | 9.462 | 0.005 | 0.85 | 0.05 |
| 2219 | Mannucci | 8/17-18, 8/26-27 | 69 | | | 0.30 | 0.05 |
| 3045 | Alois | 8/17-18, 8/26-27 | 57 | | | 0.52 | 0.04 |
| 3422 | Reid | 8/17-18, 8/26-27 | 52 | 3.22 | 0.01 | 0.29 | 0.02 |
| 3819 | Robinson | 10/22-24 | 86 | | | 0.31 | 0.04 |
| 5832 | Martaprincipe | 11/9-10, 11/14 | 54 | | | 0.16 | 0.06 |
| 5914 | Kathywhaler | 8/14-15, 8/17-18 | 79 | | | 0.22 | 0.04 |
| 6066 | Hendricks | 11/9-10, 11/14 | 56 | 5.780 | 0.002 | 0.63 | 0.02 |
| 6734 | Benzenberg | 08/11-13 | 44 | | | 0.19 | 0.07 |
| 7774 | 1992 UU2 | 10/20-21 | 21 | 3.866 | 0.004 | 0.54 | 0.04 |
| 9199 | 1993 FO1 | 8/17-18, 8/26-27 | 58 | 5.322 | 0.002 | 0.47 | 0.03 |
| 10094 | Eijikato | 8/10-13 | 60 | 7.66 | 0.02 | 0.13 | 0.04 |
| 11064 | Dogen | 11/9-10, 11/14 | 78 | 4.1629 | 0.0005 | 0.48 | 0.05 |
| 13123 | Tyson | 8/10-15 | 118 | 3.329 | 0.001 | 0.35 | 0.02 |
| 13709 | 1998 QE13 | 10/22-24 | 87 | | | 0.47 | 0.04 |
| 14162 | 1998 TV1 | 10/7-9, 10/20-21 | 32 | | | 0.24 | 0.03 |
| 19732 | 1999 XF165 | 8/10-15 | 107 | 12.57 | 0.02 | 0.19 | 0.03 |
| 20762 | 2000 EE6 | 11/9-10, 11/14 | 53 | 8.891 | 0.002 | 0.46 | 0.01 |
| 27181 | 1999 CX1 | 8/17-18, 8/26-27 | 48 | 20.67 | 0.06 | 0.45 | 0.05 |
| 29251 | 1992 UH4 | 8/10-11, 8/13-15 | 63 | 3.0990 | 0.0012 | 0.26 | 0.04 |
| 29742 | 1999 BQ12 | 8/10-15 | 92 | 4.276 | 0.003 | 0.70 | 0.05 |
| 55760 | 1992 BL1 | 11/9-10, 11/14 | 73 | 8.079 | 0.004 | 0.32 | 0.03 |

# LIGHTCURVE ANALYSIS OF MAIN BELT ASTEROIDS 292 LUDOVICA AND 1317 SILVRETTA

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(Received: 24 March Revised: 19 April)

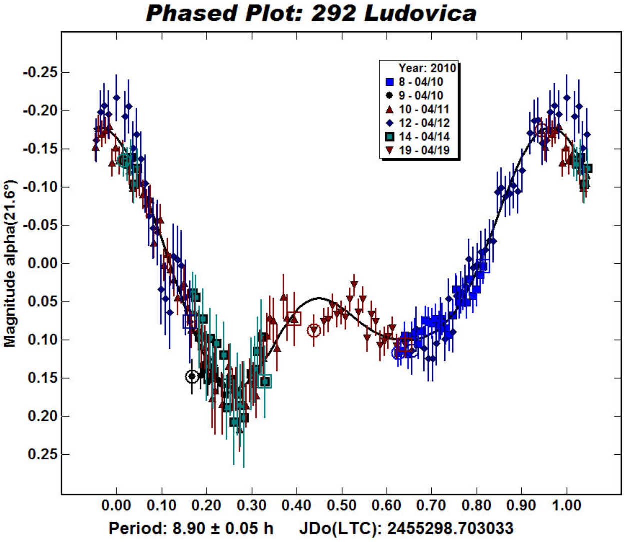
Photometric data were taken during 2009 December through 2010 April for main-belt asteroids 292 Ludovica and 1317 Silvretta. For 292 Ludovica, data analysis revealed a synodic period of 8.90 ± 0.05 h and amplitude of 0.35 ± 0.05 mag; for 1317 Silvretta, a synodic period of 7.07 ± 0.05 h and amplitude of 0.45 ± 0.05 mag were found.

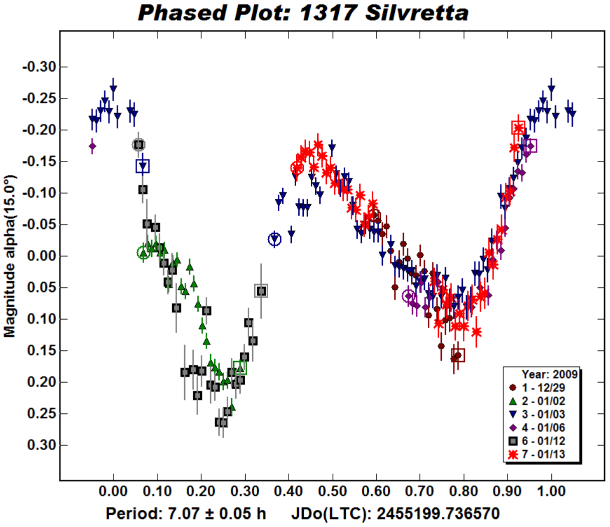
Observations were made at Shadowbox Observatory of main-belt asteroids 292 Ludovica in 2010 April and 1317 Silvretta in 2009 December and 2010 January. All observations were made with a 0.3-m Schmidt-Cassegrain (SCT) operating at f/6.1 on a German Equatorial mount (GEM). The imager was an SBIG ST9 working at 1x1 binning, which resulted in an image scale of 2.2 arc seconds/pixel. An SBIG AO-8 adaptive optics unit was employed. All images were taken through a Johnson V-band filter. The camera temperature was set in a range of –15°C to –40°C depending on ambient air temperature. Image acquisition and reduction were done with *CCDSoft*. Images were reduced with master dark and sky-flat frames. The GEM required that imaging be halted around target transit time in order to move the telescope to the other side of the pier. In order to avoid the "meridian flip" problem (Miles and Warner 2009), a new photometry session was started after each meridian flip. Other than this interruption, the camera took continuous exposures, pausing only to download each image. Exposures were 240 s for both objects.

Observations were reduced using differential photometry. Period analysis was done with *MPO Canopus*, incorporating the Fourier analysis algorithm developed by Harris et al. (1989). A minimum of two comparison stars from the UCAC3 catalog were used on each image.

292 Ludovica. This asteroid was observed from 2010 April 10-14 in support of a call for lightcurves of asteroids occulting stars on the Collaborative Asteroid Lightcurve Link website (CALL, Warner et al., 2010) to assist in determining the rotation phase at the time of a stellar occultation. In this case, Ludovica occulted SAO 61409 at about 03:29 UT on 2010 April 10. Previous observations of this object include those of Binzel (1987), who reported a rotational period of 8.93 h ± 0.02 h and an amplitude of 0.35 mag. A total of 189 data points were analyzed to find the lightcurve parameters, which were *P* = 8.90 ± 0.05 h and *A* = 0.35 ± 0.05 mag.

1317 Silvretta. This asteroid was observed on 2009 December 29 and between 2010 January 2-13. It was selected as a target of opportunity due to another target being unavailable. A quick check of the asteroid lightcurve parameters data file on the CALL site (Warner et al. 2010) revealed a wide difference in the published rotation periods. Schober and Schroll (1983) reported a period of 7.048 h, while Behrend (2010) reported a period of 3.86 h. The classical assumption is that asteroid lightcurves are bimodal for objects having lightcurve amplitude of 0.2 mag or more (Binzel 1987). If the 3.86 h period reported by Behrend were correct, one would expect to see at least all 4 extrema in any observing session longer than 3.86 h. The author obtained one session ~5 hours in length showing an amplitude of 0.3 magnitude. During that time, only three extrema were noted. Thus, the 3.86 hour period offered by Behrend can be ruled out. The results of Schober (7.048 h) fall within the margin of error of the author's, 7.07 ± 0.05 h. A total of 203 data points comprised the data set used for analysis.





## Acknowledgements

This paper makes use of data products from The Third U.S. Naval Observatory CCD Astrograph Catalog (UCAC2).

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# GENERAL REPORT OF POSITION OBSERVATIONS BY THE ALPO MINOR PLANETS SECTION FOR THE YEAR 2009

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(Received: 30 March)

Observations of positions of minor planets by members of the Minor Planets Section in calendar year 2009 are summarized.

During the year 2009 a total of 1344 positions of 318 different minor planets were reported by members of the Minor Planets Section. Of these 325 are CCD images (denoted C), 60 are precise photographic measures (denoted P), and all the rest are approximate visual positions.

The summary lists minor planets in numerical order, the observer and telescope aperture (in cm), UT dates of the observations, and the total number of observations in that period. The year is 2009 in each case.

Positional observations were contributed by the following observers:

| Observer, Instrument | Location | Planets | Positions |
|---|---|---|---|
| Arlia, Saverio<br>20 cm f/6 reflector | Buenos Aires, Argentina | 5 | 60P |
| Bookamer, Richard E.<br>41 cm reflector | Sebastian, Florida USA | 38 | 130 |
| Faure, Gerard<br>20 cm Celestron, | Col de l'Arzelier, France | 72 | 394 (265C) |
| Garrett, Lawrence<br>32 cm f/6 reflector | Fairfax, Vermont, USA | 12 | 26 |
| Harvey, G. Roger<br>74 cm Newtonian | Concord, North Carolina, USA | 119 | 432 |
| Hudgens, Ben<br>40 cm f/4.5 Dobsonian<br>63 cm f/4.5 Dobsonian | Stephenville, Texas, USA and environs | 85 | 182 |
| Martinez, Luis<br>28 cm f/6.3 SCT | Casa Grande AZ, USA | 14 | 60C |
| Pryal, Jim<br>20 cm f/10 SCT<br>12 cm f/8.33 refractor | Federal Way, WA USA and environs | 14 | 41 |
| Watson, William W.<br>20 cm Celestron | Tonawanda, NY USA and vicinity. | 6 | 19 |

| MINOR PLANET | OBSERVER & APERTURE (cm) | OBSERVING PERIOD (2006) | NO. OBS. |
|---|---|---|---|
| 1 Ceres | Pryal, 12<br>Watson, 20 | Feb 19-Apr 30<br>Mar 1-16 | 7<br>5 |
| 3 Juno | Pryal, 12 | Sep 12-13 | 2 |
| 33 Polyhymnia | Pryal, 20 | Jul 20-22 | 4 |
| 53 Kalypso | Watson, 20 | Nov 12-Dec 13 | 3 |
| 54 Alexandra | Arlia, 20 | Apr 1-27 | 15P |
| 70 Panopaea | Pryal, 20 | May 21-24 | 3 |
| 81 Terpsichore | Garrett, 32 | Nov 19 | 2 |
| 88 Thisbe | Faure, 20 | Aug 24-25 | 2 |
| 103 Hera | Pryal, 20 | May 21-24 | 4 |
| 140 Siwa | Pryal, 20 | Jul 29 | 2 |
| 148 Gallia | Arlia, 20 | Sep 16-Nov 12 | 26P |
| 161 Athor | Watson, 20 | Sep 13-20 | 3 |
| 164 Eva | Arlia, 20<br>Watson, 20 | Nov 20<br>Nov 13-18 | 2P<br>2 |
| 165 Loreley | Pryal, 20 | Aug 20-21 | 2 |
| 176 Iduna | Arlia, 20 | Jun 20-23 | 3P |
| 200 Dynamene | Garrett, 32 | May 25 | 2 |
| 212 Medea | Garrett, 32 | Oct 10 | 2 |
| 215 Oenone | Garrett, 32 | May 25 | 2 |
| 244 Sita | Garrett, 32 | Oct 20 | 2 |
| 257 Silesia | Garrett, 32 | Oct 20 | 2 |
| 269 Justitia | Pryal, 20 | May 21 | 2 |
| 288 Glauke | Bookamer, 41 | Feb 13 | 3 |
| 319 Leona | Hudgens, 40 | Jul 25 | 2 |
| 330 Adalberta | Hudgens, 40 | Aug 11-17 | 3 |
| 383 Janina | Bookamer, 41 | Dec 8 | 3 |
| 385 Ilmatar | Watson, 20 | Feb 3-18 | 3 |
| 393 Lampetia | Martinez, 28 | Sep 14-15 | 2C |
| 394 Arduina | Harvey, 73 | Nov 28 | 3 |
| 395 Delia | Bookamer, 41 | Jul 20 | 3 |
| 397 Vienna | Garrett, 32<br>Pryal, 20 | Oct 17<br>Aug 20-21 | 2<br>2 |
| 422 Berolina | Watson, 20 | Sep 13-19 | 3 |
| 424 Gratia | Faure, 20 | May 17 | 2 |
| 433 Eros | Pryal, 20 | Aug 20-21 | 2 |
| 451 Patientia | Pryal, 20 | May 21-24 | 4 |
| 457 Alleghenia | Hudgens, 40 | Nov 12 | 2 |
| 554 Peraga | Martinez, 28 | Jun 18-19 | 2C |
| 572 Rebekka | Bookamer, 41 | Aug 20 | 3 |
| 583 Klotilde | Bookamer, 41 | Jan 14 | 2 |
| 588 Achilles | Hudgens, 40 | Oct 20 | 2 |
| 589 Croatia | Bookamer, 41 | Dec 8 | 2 |
| 605 Juvisia | Bookamer, 41 | Sep 8 | 3 |
| 610 Valeska | Hudgens, 40 | Oct 20 | 2 |
| 630 Euphemia | Bookamer, 41 | Feb 26 | 3 |
| 656 Beagle | Bookamer, 41 | Jan 16 | 3 |
| 664 Judith | Bookamer, 41 | Mar 13 | 3 |
| 681 Gorgo | Hudgens, 40 | Sep 21 | 2 |
| 686 Gersuind | Martinez, 28 | Sep 19-20 | 6C |

| MINOR PLANET | OBSERVER & APERTURE (cm) | OBSERVING PERIOD (2006) | NO. OBS. |
|---|---|---|---|
| 690 Wratislavia | Martinez, 28 | Sep 7 | 2C |
| 694 Ekard | Martinez, 28 | Jul 13-14 | 2C |
| 704 Interamnia | Arlia, 20 | Mar 20-Apr 1 | 14P |
| 708 Raphaela | Hudgens, 40 | Sep 21 | 2 |
| 711 Marmulla | Bookamer, 41 | Sep 24-Oct 13 | 5 |
| 714 Ulula | Martinez, 28 | Sep 19-20 | 6C |
| 733 Mocia | Bookamer, 41 | Feb 27 | 3 |
| 738 Alagasta | Bookamer, 41 | Mar 26 | 3 |
| 753 Tiflis | Pryal, 20 | May 21-24 | 2 |
| 772 Tanete | Pryal, 20 | May 24 | 2 |
| 781 Kartvelia | Bookamer, 41 | Jul 22 | 3 |
| 786 Bredichina | Harvey, 73 | Jan 23 | 6 |
| 788 Hohensteina | Martinez, 28 | Sep 7 | 10C |
| 821 Fanny | Hudgens, 40 | Jun 22-23 | 2 |
| 843 Nicolaia | Hudgens, 40 | Oct 20 | 2 |
| 849 Ara | Pryal, 20 | May 24 | 2 |
| 850 Altona | Bookamer, 41 | Feb 16 | 3 |
| 851 Zeissia | Bookamer, 41 | Mar 14 | 3 |
| 870 Manto | Faure, 20 | Apr 24-May 29 | 10 (3C) |
| 884 Priamus | Hudgens, 40 | Jun 21-23 | 2 |
| 891 Gunhild | Bookamer, 41 | Mar 2 | 3 |
| 904 Rockefellia | Faure, 20 | May 17 | 2 |
| 909 Ulla | Bookamer, 41 | Sep 17 | 5 |
| 928 Hildrun | Bookamer, 41 | Feb 24 | 3 |
| 946 Poësia | Bookamer, 41 | Jan 18 | 3 |
| 948 Jucunda | Hudgens, 63 | Oct 17 | 2 |
| 949 Hel | Bookamer, 41 | Feb 11 | 3 |
| 959 Arne | Faure, 20 | Feb 27 | 2 |
| | Harvey, 73 | Feb 17 | 3 |
| 962 Aslög | Hudgens, 40 | Jun 22-23 | 2 |
| 966 Muschi | Bookamer, 41 | Jul 12 | 2 |
| 978 Aidamina | Bookamer, 41 | Sep 24 | 3 |
| 982 Franklina | Faure, 20 | Oct 19 | 5C |
| 985 Rosina | Bookamer, 41 | Aug 20 | 3 |
| 1003 Lilofee | Bookamer, 41 | Jan 19 | 3 |
| 1074 Beljawskya | Bookamer, 41 | Jan 16 | 3 |
| 1081 Reseda | Hudgens, 40 | Nov 18 | 2 |
| 1104 Syringa | Hudgens, 40 | Dec 18-20 | 2 |
| 1109 Tata | Faure, 20 | Feb 27 | 2 |
| 1123 Shapleya | Bookamer, 41 | Jan 14 | 4 |
| 1130 Skuld | Bookamer, 41 | Nov 5 | 3 |
| 1165 Imprinetta | Harvey, 73 | Oct 26 | 3 |
| 1171 Rusthawelia | Bookamer, 41 | Nov 20 | 3 |
| 1172 Äneas | Hudgens, 40 | Jun 23-24 | 2 |
| 1176 Lucidor | Faure, 20 | Sep 29 | 2C |
| 1199 Geldonia | Faure, 20 | Aug 14 | 3 |
| 1215 Boyer | Hudgens, 40 | Nov 12 | 2 |
| 1237 Geneviève | Faure, 20 | Feb 28 | 2 |
| 1246 Chaka | Bookamer, 41 | Dec 14 | 3 |
| 1256 Normannia | Hudgens, 40 | Aug 20-22 | 2 |
| 1271 Isergina | Faure, 20 | Oct 19 | 4C |
| 1277 Dolores | Bookamer, 41 | Sep 9 | 3 |
| 1280 Baillauda | Faure, 20 | Sep 28 | 4 |
| 1298 Nocturna | Hudgens, 40 | Sep 21 | 2 |
| 1300 Marcelle | Faure, 20 | Apr 24-May 29 | 13 (11C) |
| | Harvey, 73 | May 20 | 3 |
| 1303 Luthera | Garrett, 32 | May 25 | 2 |
| 1317 Silvretta | Bookamer, 41 | Nov 20 | 3 |
| 1343 Nicole | Faure, 20 | Feb 28 | 2 |
| 1345 Potomac | Hudgens, 40 | Nov 18 | 2 |
| 1351 Uzbekistania | Bookamer, 41 | Dec 14 | 4 |
| 1358 Gaika | Hudgens, 40 | Jul 26 | 2 |
| 1372 Haremari | Hudgens, 40 | Oct 24 | 2 |
| 1398 Donnera | Bookamer, 41 | Sep 17 | 3 |
| 1406 Komppa | Faure, 20 | Mar 21-22 | 3 |
| 1431 Luanda | Bookamer, 41 | Jul 16 | 3 |
| 1442 Corvina | Hudgens, 40 | Sep 25 | 2 |
| 1492 Oppolzer | Hudgens, 40 | Jul 16 | 2 |
| 1506 Xosa | Hudgens, 40 | Jul 14 | 2 |
| 1530 Rantaseppä | Hudgens, 40 | Nov 12 | 2 |
| 1546 Izsák | Hudgens, 40 | Nov 12 | 2 |
| 1552 Bessel | Hudgens, 40 | Nov 18 | 2 |
| 1609 Brenda | Hudgens, 40 | Jun 22-23 | 2 |
| 1611 Beyer | Hudgens, 40 | Jul 26 | 2 |
| 1634 Ndola | Hudgens, 40 | Jul 26 | 2 |
| 1641 Tana | Hudgens, 40 | Sep 27 | 2 |
| 1671 Chaika | Garrett, 32 | Nov 19 | 2 |
| 1676 Kariba | Faure, 20 | Apr 23-24 | 2 |
| 1700 Zvezdara | Hudgens, 40 | Sep 21 | 2 |
| 1728 Goethe Link | Faure, 20 | Sep 28-Oct 19 | 5 (4C) |
| 1743 Schmidt | Faure, 20 | Mar 22 | 2 |
| 1750 Eckert | Hudgens, 40 | Oct 24 | 2 |
| 1754 Cunningham | Faure, 20 | Oct 12-13 | 2 |
| 1767 Lampland | Harvey, 73 | Aug 26 | 3 |
| 1783 Albitskij | Faure, 20 | Apr 23-24 | 3 |
| 1815 Beethoven | Hudgens, 40 | Nov 18 | 2 |
| 1828 Kashirina | Hugens, 40 | Sep 25 | 2 |
| 1835 Gajdariya | Hudgens, 40 | Nov 18 | 2 |
| 1848 Delvaux | Faure, 20 | Feb 28 | 2 |
| 1891 Gondola | Faure, 20 | Aug 25 | 2 |
| 1904 Massevitch | Hudgens, 40 | Jul 26 | 2 |
| 1909 Alekhin | Faure, 20 | Apr 24 | 2 |
| 1937 Locarno | Hudgens, 40 | Sep 25 | 2 |
| 1984 Fedynskij | Hudgens, 40 | Aug 18-19 | 3 |
| 1994 Shane | Faure, 20 | Aug 20 | 2 |
| 1997 Leverrier | Hudgens, 40 | Sep 21 | 2 |
| 2024 McLaughlin | Harvey, 73 | Dec 11 | 3 |
| 2035 Stearns | Hudgens, 40 | Jun 22-23 | 2 |

| MINOR PLANET | OBSERVER & APERTURE (cm) | OBSERVING PERIOD (2006) | NO. OBS. |
|---|---|---|---|
| 2051 Chang | Faure, 20 | Aug 24-25 | 2 |
| 2093 Genichesk | Hudgens, 40 | Sep 21 | 2 |
| 2111 Tselina | Faure, 20 | Feb 27 | 2 |
| 2117 Danmark | Harvey, 73 | Nov 21 | 3 |
| 2138 Swissair | Hudgens, 40 | Sep 25 | 2 |
| 2219 Mannucci | Hudgens, 40 | Aug 22-23 | 2 |
| 2235 Vittore | Hudgens, 40 | Dec 18-20 | 2 |
| 2263 Shaanxi | Hudgens, 40 | Sep 27 | 2 |
| 2324 Janice | Hudgens, 40 | Jul 26 | 2 |
| 2326 Tololo | Hudgens, 40 | Nov 12 | 2 |
| 2385 Mustel | Hudgens, 40 | Aug 20-22 | 2 |
| 2452 Lyot | Harvey, 73 | Mar 22 | 3 |
| 2460 Mitlincoln | Faure, 20 | Feb 28 | 2 |
| 2480 Papanov | Hudgens, 40 | Nov 12-18 | 4 |
| 2532 Sutton | Hudgens, 40 | Aug 19 | 2 |
| 2604 Marshak | Hudgens, 40 | Jul 14-15 | 2 |
| 2612 Kathryn | Faure, 20 | May 29-30 | 8C |
| 2672 Písek | Hudgens, 40 | Aug 19 | 2 |
| 2680 Mateo | Harvey, 73 | Oct 19 | 3 |
| 2714 Matti | Hudgens, 40 | Jul 26 | 2 |
| 2771 Polzunov | Faure, 20 | Oct 19 | 5C |
| 2784 Domeyko | Hudgens, 40 | Jul 14-15 | 2 |
| 2798 Vergilius | Harvey, 73 | Oct 25-26 | 3 |
| 2816 Pien | Hudgens, 40 | Sep 25 | 2 |
| 2856 Röser | Faure, 20 | Aug 25 | 2 |
| 2867 Šteins | Faure, 20 | Oct 12 | 2 |
| 2927 Alamosa | Harvey, 73 | Oct 19 | 3 |
| 2939 Coconino | Harvey, 73 | Mar 21 | 3 |
| 2949 Kaverznez | Faure, 20 | Aug 24-25 | 2 |
| 3105 Stumpff | Hudgens, 40 | Jul 14-25 | 4 |
| 3179 Beruti | Harvey, 73 | Dec 8 | 3 |
| 3253 Gradie | Harvey, 73 | Apr 23 | 3 |
| 3265 Fletcher | Harvey, 73 | Oct 19 | 3 |
| 3279 Solon | Hudgens, 40 | Sep 21 | 2 |
| 3306 Byron | Faure, 20 | Aug 20 | 2 |
| 3453 Dostoevsky | Faure, 20 | Mar 22 | 2 |
| 3467 Bernheim | Harvey, 73 | Feb 17 | 3 |
| 3548 Eurybates | Harvey, 73 | Nov 9 | 3 |
| 3560 Chenqian | Faure, 20 | Mar 21-22 | 2 |
| 3563 Canterbury | Hudgens, 40 | Jun 21-23 | 2 |
| 3565 Ojima | Harvey, 73 | Dec 8 | 3 |
| 3567 Alvema | Hudgens, 40 | Oct 24 | 2 |
| 3600 Archimedes | Harvey, 73 | Mar 22 | 3 |
| 3616 Glazunov | Harvey, 73 | Mar 21 | 3 |
| 3730 Hurban | Hudgens, 40 | Aug 19 | 2 |
| 3760 Poutanen | Harvey, 73 | May 20 | 3 |
| 3785 Kitami | Harvey, 73 | Nov 16 | 3 |
| 3813 Fortov | Harvey, 73 | Oct 19 | 3 |
| 3832 Shapiro | Harvey, 73 | Nov 8 | 3 |
| 3843 OISCA | Harvey, 73 | Dec 17 | 3 |
| 3873 Roddy | Faure, 20 | May 30 | 2C |
| 3901 Nanjingdaxue | Faure, 20 | Apr 24 | 2 |
| 3911 Otomo | Harvey, 73 | Sep 12 | 3 |
| 3913 Chemin | Faure, 20 | Apr 24 | 2 |
| 4038 Kristina | Harvey, 73 | Sep 12 | 3 |
| 4073 Ruianzhongxue | Faure, 20 | Aug 25-Oct 14 | 5 (3C) |
| 4080 Galinskij | Faure, 20 | Aug 24-25 | 2 |
|  | Hudgens, 40 | Aug 19-22 | 4 |
| 4086 Podalirius | Harvey, 73 | Dec 8 | 3 |
| 4089 Galbraith | Hudgens, 40 | Aug 20-22 | 2 |
| 4285 Hulkower | Faure, 20 | May 16 | 2 |
|  | Harvey, 73 | Mar 22 | 3 |
| 4292 Aoba | Harvey, 73 | Feb 17 | 3 |
| 4336 Jasniewicz | Harvey, 73 | Sep 12 | 3 |
| 4343 Tetsuya | Martinez, 28 | Oct 17 | 2C |
| 4408 Zlata Koruna | Harvey, 73 | Aug 26 | 3 |
| 4417 Lecar | Harvey, 73 | Mar 30 | 3 |
| 4507 1990 FV | Harvey, 73 | Feb 17 | 3 |
| 4593 Reipurth | Harvey, 73 | Oct 20 | 3 |
| 4606 Saheki | Faure, 20 | Feb 27-28 | 2 |
| 4762 Dobrynya | Harvey, 73 | Feb 17 | 3 |
| 4763 Ride | Harvey, 73 | Feb 17 | 3 |
| 4843 Megantic | Hudgens, 40 | Sep 21 | 2 |
| 4912 Emilhaury | Harvey, 73 | Dec 11 | 3 |
| 4995 Griffin | Faure, 20 | Oct 19 | 3C |
| 4998 Kabashima | Harvey, 73 | Feb 17 | 3 |
| 5026 Martes | Faure, 20 | Aug 14-20 | 4 |
|  | Hudgens, 40 | Aug 20-22 | 2 |
| 5118 Elnapoul | Faure, 20 | Sep 23 | 2 |
|  | Hudgens, 40 | Sep 22 | 2 |
| 5135 Nibutani | Harvey, 73 | Mar 19 | 3 |
| 5150 Fellini | Harvey, 73 | Feb 23 | 3 |
| 5202 1983 XX | Harvey, 73 | Dec 11 | 3 |
| 5231 Verne | Faure, 20 | May 29 | 5C |
|  | Harvey, 73 | May 20 | 3 |
| 5246 Migliorini | Harvey, 73 | Oct 19 | 3 |
| 5294 Onnetoh | Harvey, 73 | Dec 21 | 3 |
| 5755 1992 OP7 | Harvey, 73 | Nov 28 | 3 |
| 5776 1989 UT2 | Harvey, 73 | Jul 25 | 3 |
| 5778 Jurafrance | Harvey, 73 | Aug 26 | 3 |
| 5814 1988 XW1 | Harvey, 73 | Dec 8 | 3 |
| 5850 Masaharu | Harvey, 73 | Nov 7 | 3 |
| 5887 Yauza | Harvey, 73 | Nov 8 | 3 |
| 5913 1990 BU | Hudgens, 40 | Sep 27 | 2 |
| 6003 1988 VO1 | Faure, 20 | Aug 14 | 2 |
| 6014 Chribrenmark | Harvey, 73 | Sep 12 | 3 |
| 6027 1993 SS2 | Hudgens, 40 | Jul 26 | 2 |
| 6141 Durda | Harvey, 73 | Nov 16 | 3 |
| 6198 Shirakawa | Harvey, 73 | Jan 21 | 3 |

| MINOR PLANET | OBSERVER & APERTURE (cm) | OBSERVING PERIOD (2006) | NO. OBS. |
|---|---|---|---|
| 6363 Doggett | Harvey, 73 | Jan 23 | 3 |
| 6398 Timhunter | Faure, 20 | Apr 23 | 2 |
| 6406 1992 MJ | Faure, 20 | May 30 | 2 |
| 6560 Pravdo | Hudgens, 40 | Jul 14-22 | 3 |
| 6634 1987 KB | Hudgens, 40 | Jun 22-23 | 2 |
| 6792 Akiyamatakashi | Hudgens, 40 | Sep 21 | 2 |
| 6873 Tasaka | Harvey, 73 | Apr 23 | 3 |
| 7299 Indiawadkins | Harvey, 73 | Dec 17 | 3 |
| 7305 Ossakajusto | Faure, 20 | Aug 14-25 | 4 |
|  | Hudgens, 40 | Aug 20-22 | 2 |
| 7588 1992 FJ1 | Harvey, 73 | Mar 19 | 3 |
| 8067 Helfenstein | Harvey, 73 | Sep 12 | 3 |
| 8151 Andranada | Harvey, 73 | Mar 30 | 3 |
| 8272 1989 SG | Harvey, 73 | Jan 2 | 3 |
| 8338 Ralhan | Harvey, 73 | May 20 | 3 |
| 8359 1989 WD | Harvey, 73 | Mar 30 | 5 |
| 8369 1991 GR | Hudgens, 40 | Nov 12-18 | 4 |
| 8404 1995 AN | Harvey, 73 | Jan 22 | 3 |
| 8778 1931 TD3 | Harvey, 73 | Oct 9 | 3 |
| 9144 Hollisjohnson | Harvey, 73 | Oct 8 | 3 |
|  | Hudgens, 40 | Sep 25 | 2 |
| 9515 Dubner | Faure, 20 | Oct 19 | 5C |
|  | Harvey, 73 | Oct 9 | 3 |
| 9898 1996 DF | Harvey, 73 | Dec 17 | 3 |
| 10262 Samoilov | Harvey, 73 | Nov 7 | 3 |
| 10711 Pskov | Harvey, 73 | Oct 8 | 3 |
| 12721 1991 PB | Harvey, 73 | Sep 12 | 3 |
| 12867 Joeloic | Faure, 20 | Aug 20-Nov 6 | 217 (202C) |
|  | Harvey, 73 | Oct 19 | 3 |
| 14339 1983 GU | Hudgens, 40 | Aug 20-22 | 2 |
| 15422 1998 QP45 | Harvey, 73 | Mar 22 | 3 |
| 15677 1980 TZ25 | Harvey, 73 | Nov 9 | 3 |
| 15730 1990 UA1 | Harvey, 73 | Jan 22 | 3 |
| 15967 Clairearmstrong | Harvey, 73 | Nov 27 | 3 |
|  | Hudgens, 40 | Dec 18-20 | 2 |
| 16958 Klaasen | Harvey, 73 | Feb 23 | 6 |
| 17274 2000 LC16 | Harvey, 73 | Aug 25 | 3 |
|  | Hudgens, 40 | Jul 15 | 2 |
| 18434 Mikesandras | Harvey, 73 | Jan 21 | 3 |
| 18897 2000 HG30 | Hudgens, 40 | Jul 15 | 2 |
| 19495 1998 KZ8 | Harvey, 73 | Jan 2 | 3 |
| 20810 2000 SE266 | Harvey, 73 | Dec 11 | 3 |
| 22104 2000 LN19 | Harvey, 73 | Dec 11 | 3 |
| 24101 Cassini | Harvey, 73 | Jan 21 | 3 |
| 26471 2000 AS152 | Hudgens, 40 | Aug 19 | 2 |
| 28610 2000 EM158 | Hudgens, 40 | Aug 19 | 2 |
| 29242 1992 HB4 | Harvey, 73 | Oct 19 | 3 |
| 29308 1993 UF1 | Faure, 20 | Oct 12 | 2 |
|  | Harvey, 73 | Oct 19 | 3 |
| 29780 1999 CJ50 | Harvey, 73 | Jan 2 | 3 |
| 31368 1998 WW23 | Harvey, 73 | Mar 18 | 3 |
| 31638 1999 GL32 | Harvey, 73 | Oct 25 | 3 |
| 33903 2000 KH68 | Harvey, 73 | Jul 2 | 3 |
| 42284 2001 TV8 | Harvey, 73 | Oct 19 | 3 |
| 50713 2000 EZ135 | Harvey, 73 | Oct 19 | 3 |
| 52768 1998 OR2 | Faure, 20 | Feb 28 | 3 |
|  | Harvey, 73 | Feb 1 | 3 |
| 54660 2000 UJ1 | Harvey, 73 | Nov 6 | 6 |
| 55760 1992 BL1 | Hudgens, 40 | Dec 18-20 | 2 |
| 56283 1999 LU1 | Harvey, 73 | Dec 22 | 3 |
| 58147 1986 WK | Harvey, 73 | Oct 20 | 4 |
| 68350 2001 MK3 | Harvey, 73 | Jan 22 | 3 |
| 93768 2000 WN22 | Faure, 20 | Apr 24 | 3 |
|  | Harvey, 73 | May 20 | 3 |
| 136849 1998 CS1 | Bookamer, 41 | Jan 17 | 7 |
|  | Harvey, 73 | Jan 2 | 6 |
| 138883 2000 YL29 | Harvey, 73 | Sep 22 | 3 |
| 141052 2001 XR1 | Harvey, 73 | Jan 15 | 6 |
| 152664 1998 FW4 | Harvey, 73 | Sep 24 | 6 |
|  | Hudgens, 40 | Sep 25 | 2 |
| 159402 1999 AP10 | Bookamer, 41 | Sep 24 | 5 |
|  | Garrett, 32 | Oct 10 | 3 |
|  | Faure, 20 | Oct 12 | 4 |
|  | Harvey, 73 | Sep 24 | 3 |
|  | Hudgens, 40 | Sep 25 | 2 |
| 164121 2003 YT1 | Harvey, 73 | Oct 29 | 6 |
| 207945 1991 JW | Harvey, 73 | May 19 | 6 |
| 208023 1999 AQ10 | Bookamer, 41 | Feb 14 | 10 |
|  | Harvey, 73 | Feb 13 | 6 |
| 217796 2000 TO64 | Garrett, 32 | Nov 7 | 3 |
|  | Harvey, 73 | Nov 5 | 6 |
|  | Hudgens, 40 | Nov 18 | 2 |
| 217807 2000 XK44 | Garrett, 32 | Nov 8 | 2 |
|  | Harvey, 73 | Oct 29 | 6 |
|  | Hudgens, 40 | Nov 18 | 2 |
| 2000 CO101 | Harvey, 73 | Sep 24 | 3 |
| 2001 FE90 | Harvey, 73 | Jun 27 | 6 |
| 2005 RQ6 | Harvey, 73 | Oct 25 | 6 |
| 2007 MK13 | Harvey, 73 | Dec 22 | 6 |
| 2008 EE5 | Harvey, 73 | Feb 13 | 6 |
| 2008 SV11 | Harvey, 73 | Mar 30 | 6 |
| 2008 YZ32 | Martinez, 28 | Dec 31 | 4C |
| 2009 DO111 | Faure, 20 | Mar 16 | 7 |
|  | Harvey, 73 | Mar 18 | 6 |
| 2009 FH6 | Harvey, 73 | Mar 18 | 6 |
| 2009 JM2 | Harvey, 73 | May 19 | 6 |
| 2009 KC3 | Harvey, 73 | Sep 24 | 6 |
| 2009 MC9 | Martinez, 28 | Oct 15 | 3C |
| 2009 ST19 | Martinez, 28 | Nov 8 | 10C |
| 2009 TK12 | Martinez, 28 | Nov 8 | 3C |
| 2009 XD | Martinez, 28 | Dec 19 | 5C |
| 2009 XR2 | Harvey, 73 | Dec 21 | 6 |
|  | Martinez, 28 | Dec 23 | 3C |

# LIGHTCURVE PHOTOMETRY OF 112 IPHIGENIA

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(Received: 19 March)

The main-belt asteroid 112 Iphigenia was observed over 6 nights between 2007 December 9 and December 14 at the Observatorio Astronomico de Mallorca (620). From the resulting data, we determined a synodic rotation period of 31.385 ± 0.006 h and lightcurve amplitude of 0.30 ± 0.02 mag.

122 Iphigenia was tracked over 6 nights between 2007 December 9 and December 14 with one, and sometimes two, identical telescopes (0.30-m f/9 Schmidt-Cassegrain) located at the Observatorio Astronomico de Mallorca in Spain. Both were equipped with an SBIG STL-1001E CCD camera. Image acquisition and calibration were performed using *Maxim DL*. All 1593 images were unfiltered and had exposures of 60 seconds. Image analysis was accomplished using differential aperture photometry with *MPO Canopus*. Period analysis was also done in *Canopus*, which implements the algorithm developed by Harris (Harris et al., 1989). From the data we determined a synodic period of 31.385 ± 0.006 h and a lightcurve amplitude of 0.30 ± 0.02 mag. The results are in good agreement with those reported by Pilcher (2008).

Acknowledgements

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## References

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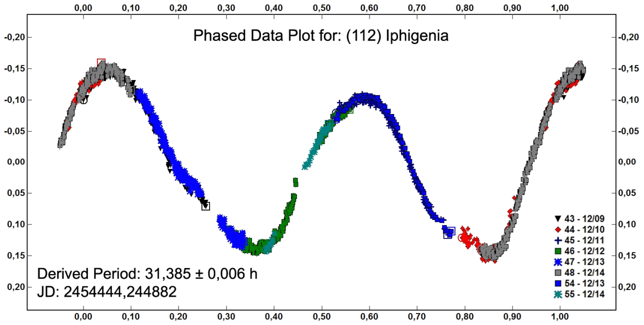

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# MINOR PLANET LIGHTCURVE ANALYSIS OF 347 PARIANA AND 6560 PRAVDO

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Minor planet 347 Pariana was observed in 2009 July and again in 2009 August and September resulting in two complete lightcurves both with a rotational period estimate of 4.052 ± 0.002 h and amplitude of 0.5 mag. These data were combined with data from previous apparitions to produce estimates for a sidereal period, spin axis, and shape model. Minor planet 6560 Pravdo was observed over nine nights in 2009 June and July resulting in a rotational period estimate of 19.229 ± 0.004 h and amplitude of 0.5 mag.

Equipment and imaging techniques employed at BDI Observatory are as described in Caspari (2008). The resulting images were measured using MPO Canopus (Warner 2010a), which uses differential aperture photometry to determine the values used for analysis. The MPO Canopus "derived magnitudes" mode was employed without the reduced magnitudes option. MPO Canopus applies distance corrections and adjusts magnitudes based on the first session centered on a mean magnitude. LC Invert (Warner 2010b) was used for the sidereal period search, spin axis and shape modeling solutions.

<u>347 Pariana.</u> This minor planet was selected for modeling as it was listed in The Minor Planet Bulletin's "Shape/Spin Modeling Opportunities" column (Volume 36-3). It was also in a favourable sky location for BDI Observatory. Data from a total of 11 observing sessions were used in this modeling process, 5 from the SAPC website (Torppa, 2008) and 6 collected at BDI Observatory (Table 1), covering a range of phase angles from 2.9° to 15.2°.

Data from the U.S. Naval Observatory was also trialed using various weightings however it only reduced the robustness of the solution and was discarded. Period reports range between 4.05 h and 4.11 h (Denchev 2000; Lagerkvist 1992). It has been established that sparse data, such as the available data for 347 Pariana, can result in a useful sidereal period, spin axis and shape modeling solutions (Durech et al. 2009).

The LC Invert application was then used to test 612 poles with the best solutions having lower chi-squared values (see Figure 1). Initial weightings were adjusted to achieve a “dark area” of less than 1%. All solutions within 10% of the lowest chi-squared values were clustered around λ =230 ±10° and β =30 ±30° suggesting a prograde rotation. While this clustering is compelling the multiple solutions and sparse data warrant a degree of caution; this solution is very preliminary. As such the spin axis, shape model (Figure 2) and resolved sidereal period of 4.05299398h are also only preliminary.

To test the accuracy of this solution the observed lightcurves were compared to those produced by the modeling process indicating a good match in all cases. A possible alternative solution for λ ± 180° was eliminated as it had a 72% higher chi-squared value and ± β was eliminated due to a poor match when comparing observed lightcurves with those produced by the modeling process.

6560 Pravdo. This main-belt asteroid with an assumed diameter of 26.2 km is based on an assumed albedo of 0.04 (Gray 2008). This target was selected from the CALL’s lightcurve targets page (Warner 2010c) since it was relatively bright and in a favourable sky location for BDI Observatory. The target had no known period. The lightcurve exhibits a typical bimodal curve. MPO Canopus was used to determine a period of 19.229 ± 0.004 h, *A* = 0.5 mag.

## Acknowledgements

The author expresses his appreciation to Mikko Kaasalainen, Johanna Torppa, (Kaasalainen, J., Torppa, J. 2001) Joseph Durech and Brian Warner for developing the code to make the shape modeling process accessible for amateur astronomers. Particular thanks go to Brian Warner for his direct support. This shape modeling effort originated as part of the author’s studies with Swinburne Astronomy Online and thanks also go to Pamela Gay for her support and encouragement.

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| Date Range | Points | α° | PABLg° | PABLt° |
|---|---|---|---|---|
| 1991 Apr 16-17 | 52 | 14.5 | 184 | 15.5 |
| 1999 Jan 6-20 | 78 | 4 | 106.3 | 5.9 |
| 2009 Jul 20-27 | 113 | 8.4 | 316.5 | -10.8 |
| 2009 Aug 25 – Sep 10 | 93 | 10.4 | 315.9 | -11.7 |

Table 1: Observational data for 347 Pariana. Phase angle α, phase angle bisector ecliptic longitude PABLg, phase angle bisector ecliptic latitude PABLt, each given at the approximate middle of the listed observation interval.

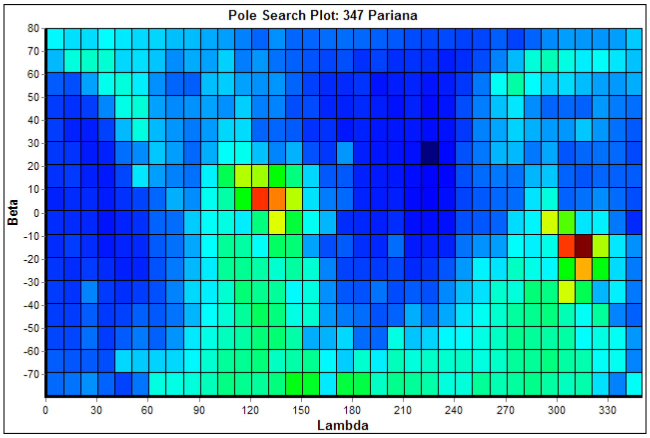


Figure 1. Pole Search results for 347 Pariana. Darker blue represents lower chi-squared values (more probable solutions). Red represents less probable solutions.

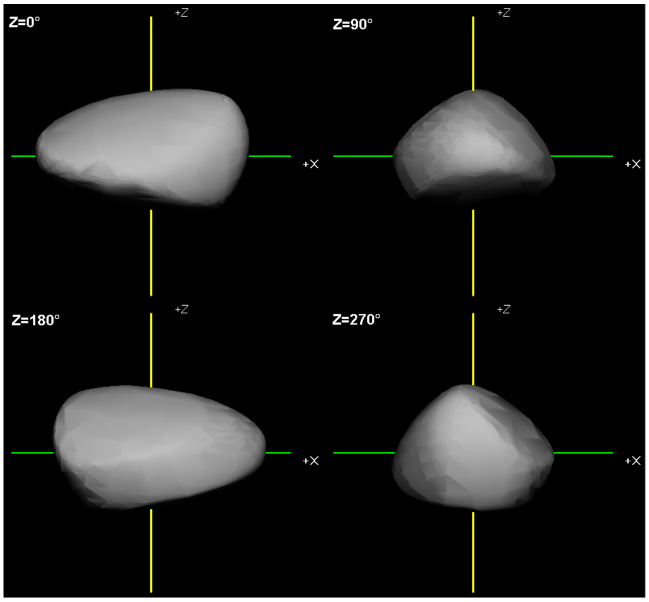
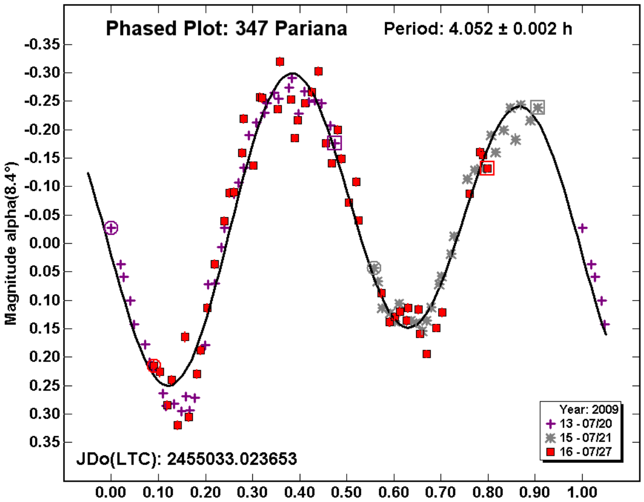
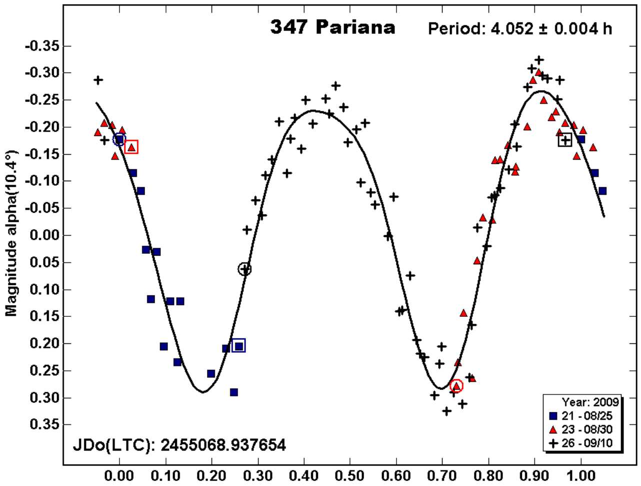
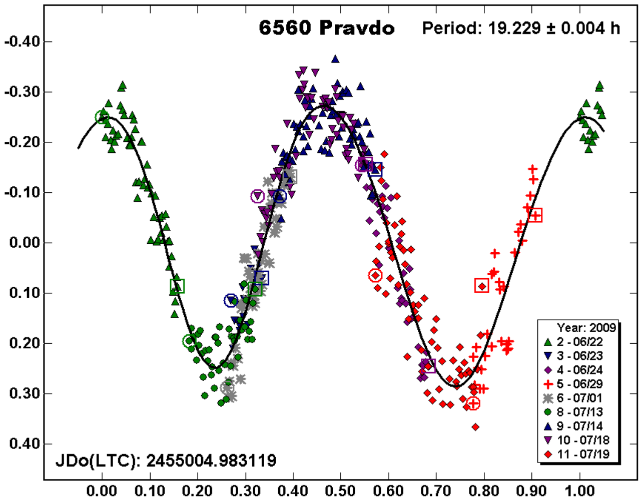


Figure 2. Equatorial view of for the output of a preliminary shape model for 347 Pariana







# A TALE OF TWO ASTEROIDS: (35055) 1984 RB AND (218144) 2002 RL66

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We present the analysis of CCD observations of the Hungaria asteroid, (35055) 1984 RB, and Mars-crosser, (218144) 2002 RL66. For 1984 RB, because of a data set spanning several weeks, we were able to determine the synodic rotation period and lightcurve amplitude as well as H and G parameters. Furthermore, the amplitude-phase angle relationship and derived value for G are consistent with a S-type asteroid. 2002 RL66 may be an unusual binary with a very long period for the primary and an asynchronous satellite that is not tidally locked to its orbit. The analysis for both of these objects relied strongly on being able to link multiple data sets onto a common system with reliable zero point calibrations.

## Observation Details

(35055) 1984 RB. This Hungaria asteroid was observed at the Palmer Divide Observatory from 2010 Feb 17 through Mar 18. A total of 583 observations were made using a 0.35-m Schmidt-Cassegrain and SBIG STL-1001E camera. Exposures were 300 s. See Warner (2010) for a general description of PDO equipment and analysis methods. See Warner (2007) and Stephens (2008) for details on data set calibration and methods using 2MASS (Skrutskie et al. 2006) to BVRI conversions. As described below, these methods were later abandoned for this asteroid after the initial data set led to erroneous conclusions.

(218144) 2002 RL66. This Mars-crosser was initially observed at the Palmer Divide Observatory from 2009 Nov 18 through Dec 11. The results were *P* = 616 h and *A* = 0.34 mag (Warner, 2010). At the time, it was noted that the combination of the period and estimated diameter would make the object a likely tumbler (in non-principal axis rotation) but no evidence was found (see Pravec et al. 2005, regarding tumbling damping times). Additional observations in 2010 March further refined the long period.

## The Best and Worst of Times

The sequence of events for these two asteroids provides an interesting study of how one thing can lead to another in data analysis and the importance of having data that can be reliably placed on a consistent internal (or standard) system. The story begins with (218144) 2000 RL66.

After submitting the paper to the *Minor Planet Bulletin* on (218144) 2002 RL66, the data were sent to Pravec and Kušnirák, who have the specialized tools to check for tumbling behavior. No evidence was found. However, Kušnirák did find a weak, second *additive* period of $P_{short}$ = 2.492 h and $A$ = 0.04 mag. This prompted the additional observations at PDO that spanned 2010 Jan 9 through Feb 13 and led to the refined lightcurve parameters for the long period of $P_{long}$ = 587 ± 10 h and $A$ = 0.25 mag. The short period parameters remained essentially the same (Figs 1/2).

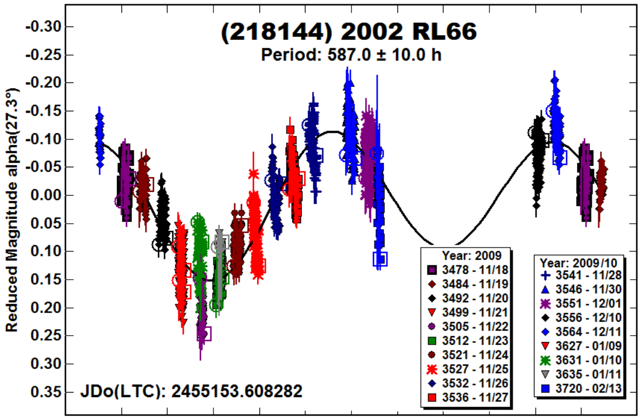

**Figure 1.** The long period lightcurve of (218144) 2002 RL66.

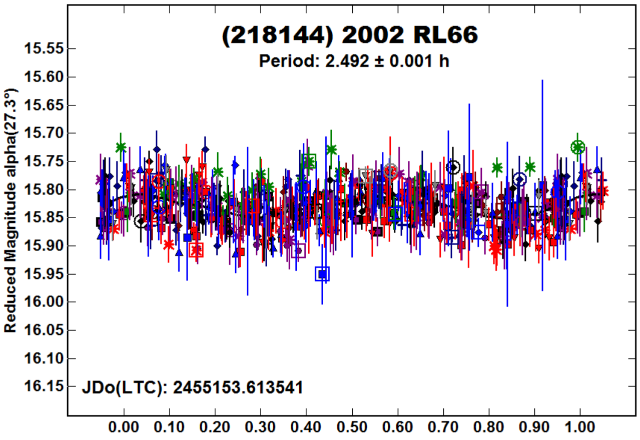

**Figure 2.** Short period lightcurve of (218144) 2002 RL66.

The presence of two *additive* periods is often an indicator for a binary system (for a detailed description of binary lightcurve analysis, see Pravec et al., 2006). However, the lack of mutual events (occultations and/or eclipses), prevented making such a claim for 218144 with certainty. If the system were binary, then it was an unusual one in that the primary period was very long while the secondary period was relatively short. Unusual, that is, until the initial data for (35055) 1984 RB were obtained and analyzed. On the presumption that the linkage of the data sets was correct, this lead to the appearance that 35055 also had two additive periods, one of ~3.658 h and another on the order of 300 h. Influenced by the findings for 218144, we looked deeper into the possibilities for systems with these characteristics.

In any *known* model for a system with two additive periods, when the combined light is at a maximum, the amplitude of the shorter period lightcurve should be less than when the combined light is at a minimum. This stems from the fact that if the variation in *intensity units* of the shorter period is the same at all times, then when the longer period component is brighter, it dilutes the shorter period curve more in *magnitude units* than when it is fainter. For example, in our initial analysis for 35055, we found a mean amplitude for the short period of 0.39 mag and 0.3 mag for the long period. Therefore, on the nights close to combined *minimum* magnitude, we would expect the short period amplitude to be about 15% *greater* than average, or about 0.45 mag, and about 15% *less* (0.34 mag) when the combined light was at *maximum*. While there was some night-to-night variation in amplitude of the short period (see below), it did not follow the pattern of larger amplitude at fainter level of the long period variation.

Using the principle of *Occam's Razor* (the simplest solution is mostly likely the correct one), the images were re-measured using SDSS (Stoughton et al., 2002) and CMC-14 (Evans et al., 2002) r' magnitudes for the comparison stars instead of the R magnitudes derived from 2MASS J-K magnitudes. The internal consistency of r' magnitudes is on the order of 0.02-0.03 mag (Dymock and Miles, 2009), thus removing some of the uncertainties in the data set linking. The result was the complete elimination of any secondary period, and the re-reduced data was well fit with a single synodic period of $P$ = 3.6586 ± 0.0005 h (Fig. 3).

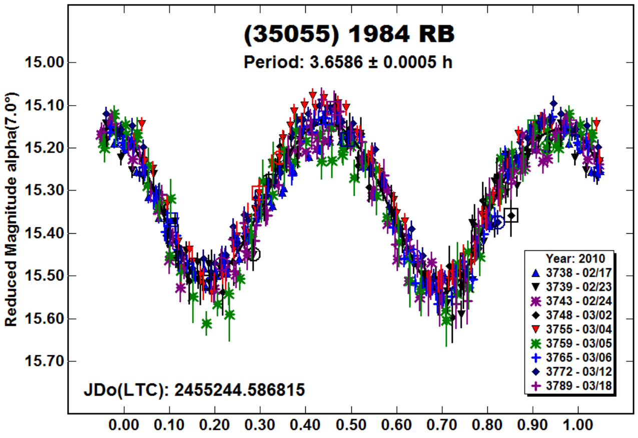

**Figure 3.** Lightcurve of (35055) 1984 RB. SDSS r' magnitudes.

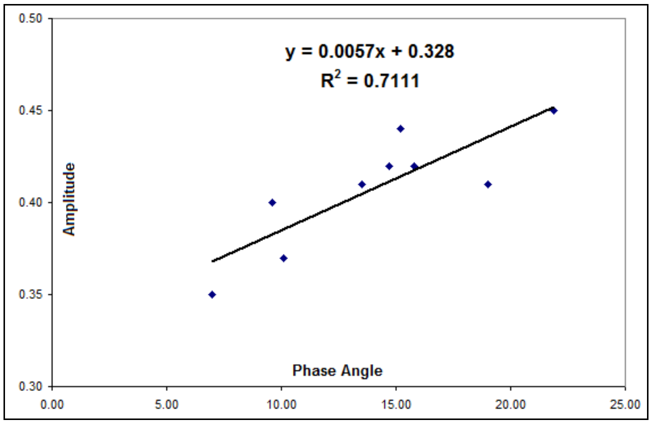

**Figure 4.** Amplitude versus phase for (35055) 1984 RB.

We plotted the amplitude versus phase angle (Fig. 4) and found a slope of ~0.006, which is in the range found for S-class asteroids by Zappala et al. (1990). We then examined the *ugriz* magnitudes from the SDSS MOC (Ivezić et al., 2001) using Principal Component Analysis (PCA) as developed by Nesvorný at el. (2005). The results were consistent with an S-type asteroid.

Since the data spanned phase angles from 7° to 22°, we also were able to determine the absolute magnitude ($H$) and phase slope parameter ($G$) for the asteroid (Fig. 5). The magnitudes in that plot are SDSS r’. The SDSS MOC gave a V-R for the asteroid of 0.44. Dymock and Miles (2009) convert r’ to R using R = r’ – 0.22, or V-r’ = 0.22 for V-R = 0.44. Combining these values with our $H_{r'}$ = 14.69, we found $H_V$ = 14.91. The value for *G* was 0.225 ± 0.025, which is consistent with the default of *G* = 0.24 ± 0.11 for S-class asteroids given by Warner et al. (2009). While none of these factors (amplitude vs. phase, colors, or phase relation) are certain determinations of S-class, together they constitute good evidence that this asteroid is of S-type. Assuming the default albedo for S-type asteroids, $p_V$ = 0.20 (Warner et al., 2009), we estimate the size of the asteroid to be $D \sim 3.1$ km.

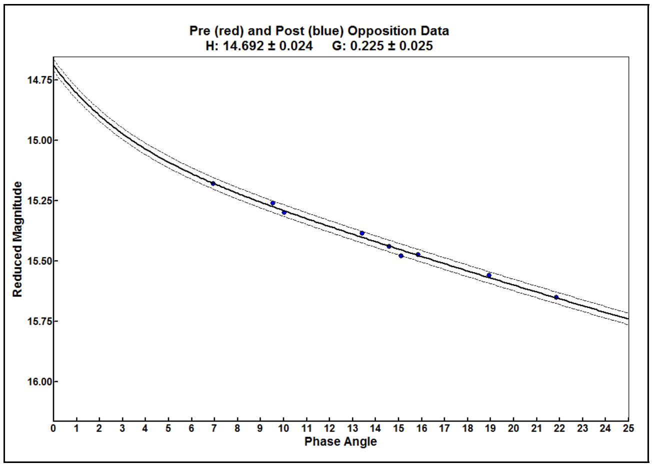

**Figure 5.** H-G plot for (35055) 1984 RB.

## Conclusions

It is important to emphasize again that we do not have conclusive evidence that (218144) 2002 RL66 is a binary system. It is possible that future adaptive optics (AO) observations, when the asteroid is sufficiently bright, can be used to see if two bodies can be resolved, and it is also possible that photometric observations at a different aspect might show eclipse events. We strongly encourage AO and additional photometric observations of low noise (~0.01 mag) at future apparitions.

While the 2MASS to BVRI conversions have been used with great success in many cases, they failed in the case of (35055). The analysis for that asteroid showed that the better thing to do is use native catalog magnitudes that are internally consistent instead of relying on conversions from one magnitude system to another. This is not always possible since the SDSS/CMC-14 catalogs do not provide complete sky coverage. Since the methods used by Warner (2007) and Dymock and Miles (2009) both rely on J-K values from the 2MASS catalog to convert to the BVRI system, it would be prudent when using those methods to have some means of cross-checking the data to confirm the results, especially if those results seem to indicate something extraordinary.

## Acknowledgements

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# ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY: 2009 DECEMBER – 2010 MARCH

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Lightcurves for 31 asteroids were obtained at the Palmer Divide Observatory (PDO) from 2009 December through 2010 March: 205 Martha, 379 Huenna, 456 Abnoba, 479 Caprera, 616 Elly, 766 Moguntia, 1069 Planckia, 1364 Safara, 3986 Rozhkovskij, 4764 Joneberhart, 4765 Wasserburg, 4868 Knushevia, 5967 Edithlevy, (6382) 1988 EL, 15786 Clairearmstrong, (18181) 2000 QD34, (19404) 1998 FO5, (31076) 1996 XH1, (33341) 1998 WA5, (33816) 2000 AL42, (36298) 2000 JF10, (41467) 2000 OG29, (43606) 2001 XQ2, (48154) 2001 GT3, (53431) 1999 UQ10, (68547) 2001 XW29, 70030 Margaretmiller, (85839) 1998 YO4, (188077) 2001 XW47, and 2000 CO101. Several of these appear to be in non-principal axis rotation (NPAR). (53431) 1999 UQ10 may have a secondary, additive period of about 38.4 h. Revised results from the 2003 apparition of 70030 Margaretmiller are also reported.

CCD photometric observations of 31 asteroids were made at the Palmer Divide Observatory (PDO) from 2009 December through 2010 March. See the introduction in Warner (2010) for a discussion of equipment, analysis software and methods, and overview of the plot scaling.

The “Reduced Magnitude” in the plots uses R magnitudes corrected to unity distance using -5 * log (Rr) with R and r being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. The magnitudes were normalized to the phase angle given in parentheses, i.e., alpha(X), using $G = 0.15$ unless otherwise stated.

205 Martha. Periods of either 9.7 or 11.9 h have been previously reported for this asteroid (see, e.g., Behrend 2010; Chiorny 2007; Hawkins 2008). The last two reported ambiguous solutions with alternate solutions that matched approximately one of the two periods above. The data obtained at the PDO in 2010 February cannot be fit to either one, and instead fit a period of 39.8 ± 0.1 h.

379 Huenna. This is a known binary system (Marchis 2008) with an orbital period of ~2100 h. Even if the satellite were large enough to detect with photometry, the odds of catching an event are extremely small. Harris et al. (1992) reported a period of 7.022 h. The PDO data indicate a period about double that, or 14.14 h.

456 Abnoba. Behrend (2010) reported a period of 18.2026 h based on observations in 2004. The period derived from PDO data revises this value. The Behrend data sets were obtained several months apart, which could result in an incorrect rotational count over the span of observations. The PDO data were obtained over a week, with individual sessions covering a little less than half the derived period.

479 Caprera. Previously reported periods include 9.4277 h (Higgins 2005), 9.425 h (Fauerbach 2005), and 9.376 h (Hawkins 2008). Behrend (2010) reports several periods of approximately 5.25 h. The PDO results give $P = 9.43 \pm 0.02$ h.

616 Elly. This result of 5.297 h agrees with Alvarez (2004).

766 Moguntia. Binzel (1987) found a period of 3.446 h while the PDO data give $P = 4.818$ h. The period spectrum, shown below, strongly favors the longer period.

1364 Safara. This asteroid happened to be in the field of a planned target. It was observed only one night but the data cover a little more than a complete cycle and the amplitude of ~0.4 mag allowed eliminating any ambiguous solutions.

3986 Rozhkovskij. Birlan (1996) found a period of 4.26 h. The PDO data yield $P = 3.548$ h, a result clearly favored in the period spectrum.

4764 Joneberhart. The author worked this asteroid in early 2007 (Warner 2007b) and found essentially the same period.

4765 Wasserburg. Earlier work by the author (Warner 2007b) found a period of 3.67 h and amplitude ($A$) of only 0.04 mag. The amplitude of $A = 0.60$ mag for this work made for a much more reliable result, $P = 3.625$ h. The Phase Angle Bisector longitudes were 70° (2006 December) and 124° (2010 January) or a difference of about 55°. Assuming the asteroid’s pole is near the ecliptic plane (based on the very low amplitude in 2006), one could infer that the longitude of the pole is near 70° or 250°.

4868 Knushevia. When observed by the author in 2008 (Warner 2009), the amplitude of the lightcurve was only 0.09 mag. It was only 0.08 mag for this apparition. The period of 4.54 h is about 0.09 h longer than reported earlier. The data from each apparition cannot be made to fit the period of the other.

5967 Edithlevy. This asteroid is almost certainly in non-principal axis rotation (NPAR). As such, the lightcurve is not the simple addition of two periods but instead is a complex combination of the rotation about the moment of least inertia and the precession of that axis (see Pravec et al. 2005 for a thorough discussion of NPAR and lightcurve analysis). In this case, a period of ~66 h dominated the solution but with the given data set it was not possible to find a unique solution for the two periods.

(6382) 1988 EL. This is the third time this asteroid has been worked at PDO (Warner, 2005; Warner, 2007a). The amplitude has always been < 0.10 mag, which makes the prospects for finding a spin and shape axis model less than favorable.

15967 Clairearmstrong. The period of 5.897 h agrees with that found by Brinsfield (2010), who observed the asteroid in early 2009 December. He reported an amplitude of 0.33 mag ($\alpha$ ~10.4°). By early 2010 January ($\alpha$ ~16°), the amplitude had increased to 0.41 mag.

(19404) 1998 FO5. A half-period search lead to the solution of $P = 10.6 \pm 0.2$ h.

(31076) 1996 XH1. This is a slow rotator, with $P$ ~350 h or ~700 h. The lightcurve has been fit to 700 h, giving a bimodal solution. However, with $A \sim 0.20$ mag, a monomodal solution (and the half period) cannot be formally excluded.

(33816) 2000 AL242. The lightcurve is fit to a period of 193 h. However, a period of ~390 h cannot be formally excluded.

(36298) 2000 JF10. This asteroid shows good indications that it is tumbling but not as dramatically as 5967 Edithlevy. The period given in the plot and table (82 h) is the one that dominated the single period search.

(41467) 2000 OG29. This object was observed only one night, when it happened to be in the same field as a program asteroid. There are several possible solutions. The lightcurve is fit to a period of 6.8 h. However, periods of 10.0 h and 14.5 h cannot be formally excluded.

(43606) 2001 XQ2. This asteroid also shows signs of tumbling (NPAR). The period of 87 h is the one that dominated the single period search.

(53431) 1999 UQ10. The data for this asteroid can be best fit by using two additive periods, $P1 = 2.650$ h and $P2 = 38.4$ h. Plots for each, subtracting out the other period, are included below. Given the noisy data, it is not possible to say with certainty that the two periods are real. On the *presumption* that the two periods do exist, a possible explanation would be a binary system. However, the evidence is too weak to raise more than speculation about the true nature of the system. Future observers should keep the possibility of dual periods in mind but remain highly skeptical.

(68547) 2001 XW29. While the period spectrum strongly favors a period of 36.7 h, there are indications that the asteroid is tumbling, at least to a small degree. The tumbling damping time (see Pravec et al. 2005) for a 37 period is ~1.6 Gyr, making it somewhat likely for the asteroid to be in an NPAR state.

70030 Margaretmiller. Images from 2003 were re-measured using the latest version of *MPO Canopus* software to verify a period of 3.98 h (Warner, 2005). Despite data with low SNR, the new analysis gave $P = 4.35$ h. The asteroid was observed in 2010 February with much higher SNR and a result of $P = 4.329$ h, confirming the revised period.

(85839) 1998 YO4. The amplitude of every data session was < 0.05 mag and the sessions showed no long-term variation. The period spectrum was as flat as the lightcurve shown below. The period to which the data were fit is not shown since it was no better (or worse) than dozens of others.

(188077) 2001 XW47. Based on only three sessions, it appears that this asteroid has a very long period. The plot is fit to $P = 525$ h, which based on the assumption that the ~0.3 mag amplitude of the session averages would indicate a bimodal solution.

## Acknowledgements

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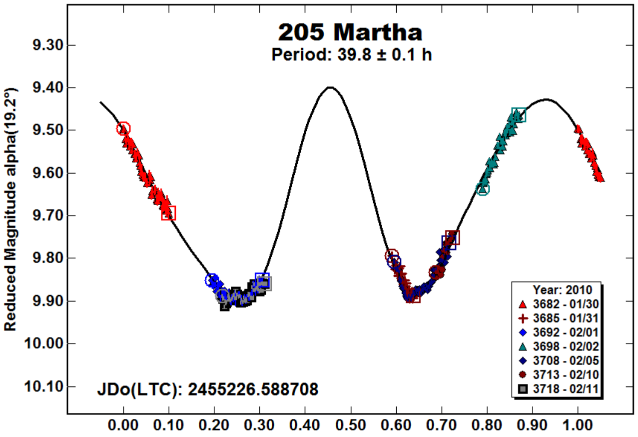
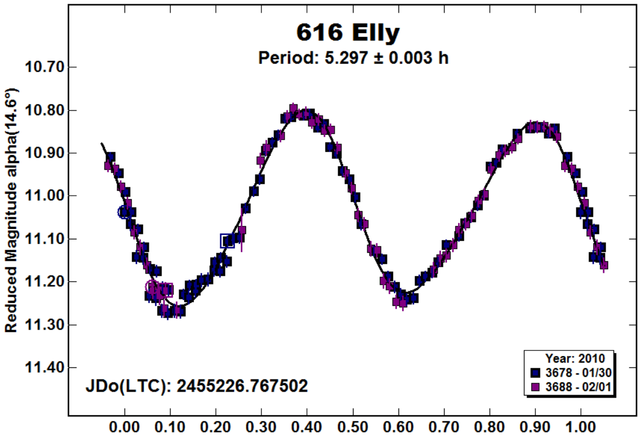
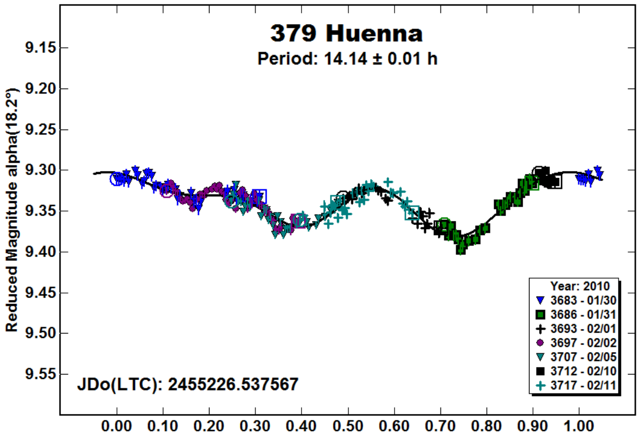
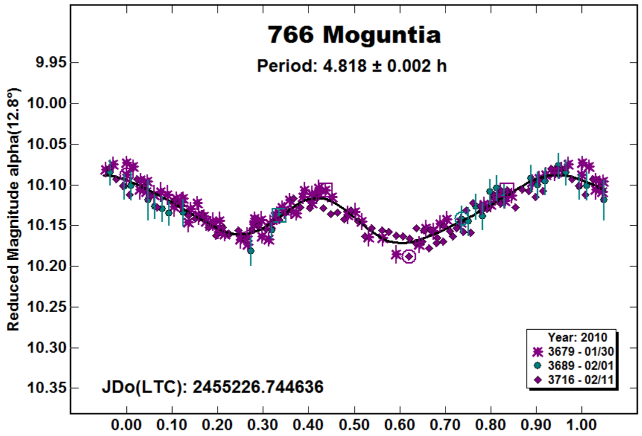
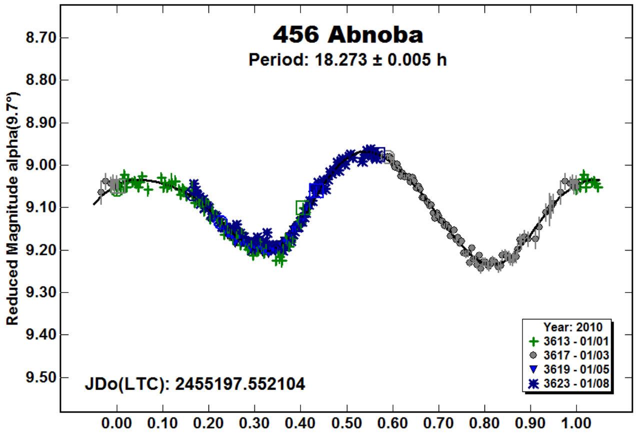
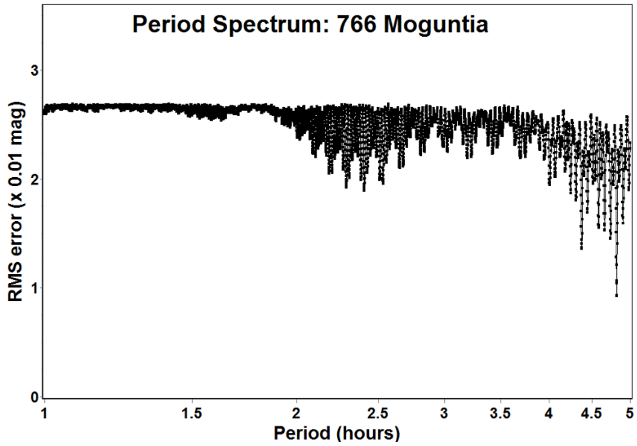

205 Martha
Period: 39.8 ± 0.1 h
Reduced Magnitude alpha(19.2°)
9.30
9.40
9.50
9.60
9.70
9.80
9.90
10.00
10.10
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2010
3682 - 01/30
3685 - 01/31
3692 - 02/01
3698 - 02/02
3708 - 02/05
3713 - 02/10
3718 - 02/11
JDo(LTC): 2455226.588708

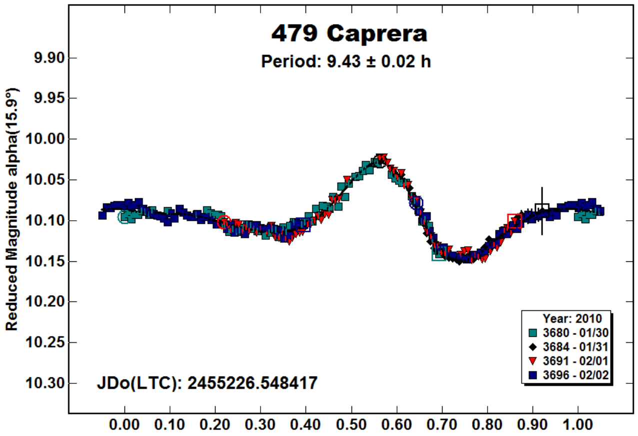

616 Elly
Period: 5.297 ± 0.003 h
Reduced Magnitude alpha(14.6°)
10.70
10.80
10.90
11.00
11.10
11.20
11.30
11.40
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2010
3678 - 01/30
3688 - 02/01
JDo(LTC): 2455226.767502

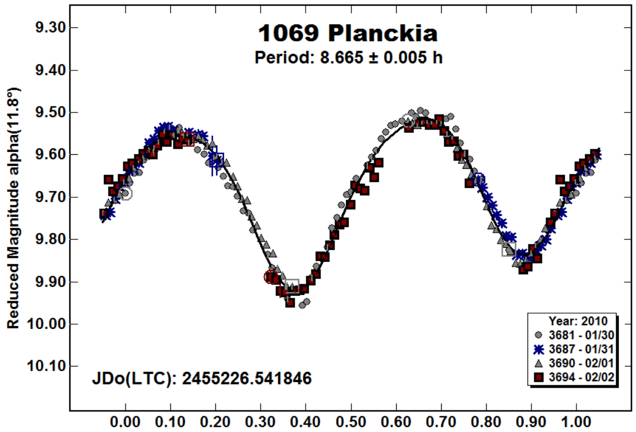

379 Huenna
Period: 14.14 ± 0.01 h
Reduced Magnitude alpha(18.2°)
9.15
9.20
9.25
9.30
9.35
9.40
9.45
9.50
9.55
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2010
3683 - 01/30
3686 - 01/31
3693 - 02/01
3697 - 02/02
3707 - 02/05
3712 - 02/10
3717 - 02/11
JDo(LTC): 2455226.537567

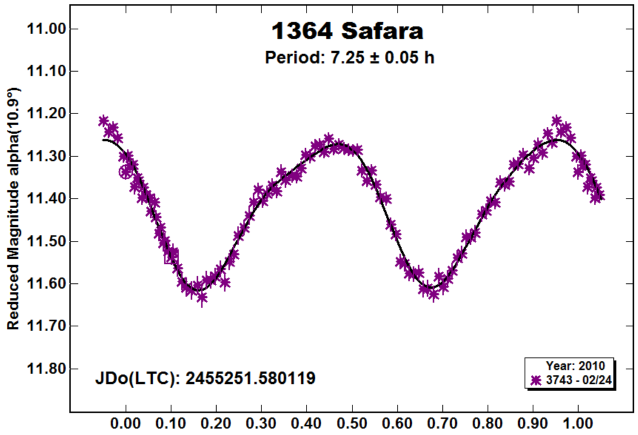

766 Moguntia
Period: 4.818 ± 0.002 h
Reduced Magnitude alpha(12.8°)
9.95
10.00
10.05
10.10
10.15
10.20
10.25
10.30
10.35
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2010
3679 - 01/30
3689 - 02/01
3716 - 02/11
JDo(LTC): 2455226.744636

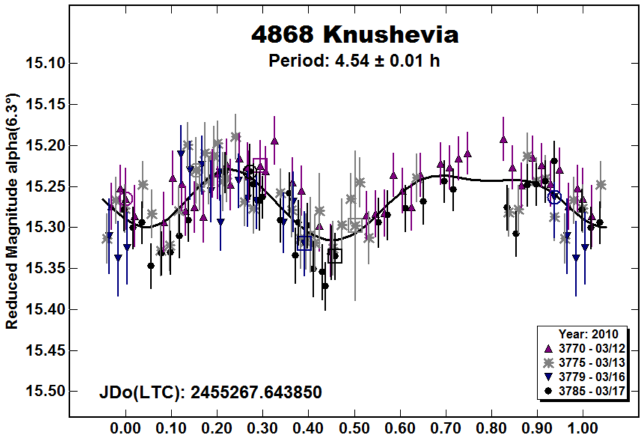

456 Abnoba
Period: 18.273 ± 0.005 h
Reduced Magnitude alpha(9.7°)
8.70
8.80
8.90
9.00
9.10
9.20
9.30
9.40
9.50
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2010
3613 - 01/01
3617 - 01/03
3619 - 01/05
3623 - 01/08
JDo(LTC): 2455197.552104

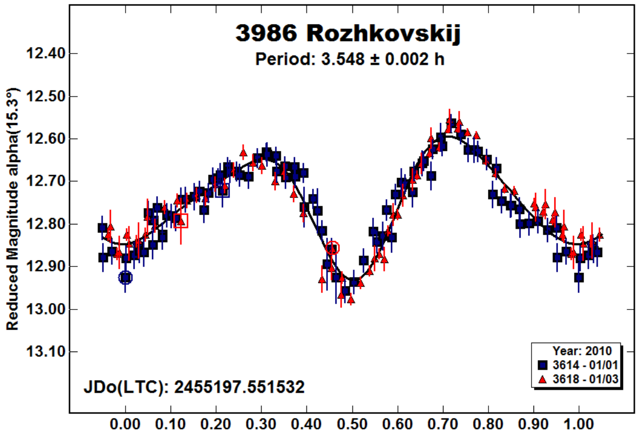

Period Spectrum: 766 Moguntia
RMS error (x 0.01 mag)
3
2
1
0
1
1.5
2
2.5
3
3.5
4
4.5
5
Period (hours)

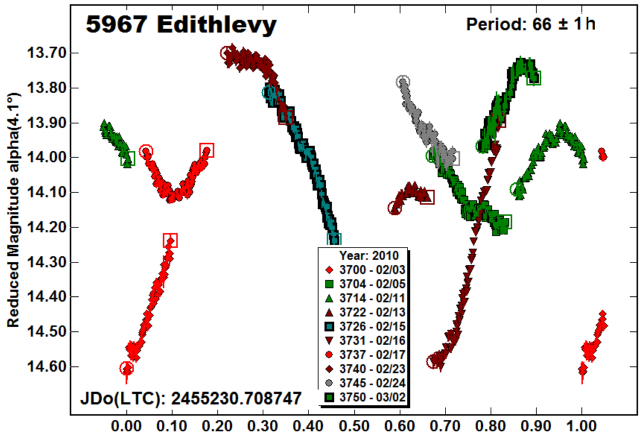

479 Caprera
Period: 9.43 ± 0.02 h
Reduced Magnitude alpha(15.9°)
9.90
9.95
10.00
10.05
10.10
10.15
10.20
10.25
10.30
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2010
3680 - 01/30
3684 - 01/31
3691 - 02/01
3696 - 02/02
JDo(LTC): 2455226.548417

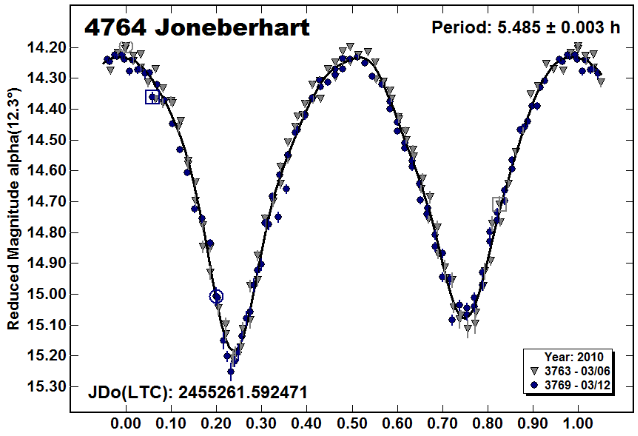

1069 Planckia
Period: 8.665 ± 0.005 h
Reduced Magnitude alpha(11.8°)
9.30
9.40
9.50
9.60
9.70
9.80
9.90
10.00
10.10
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2010
3681 - 01/30
3687 - 01/31
3690 - 02/01
3694 - 02/02
JDo(LTC): 2455226.541846

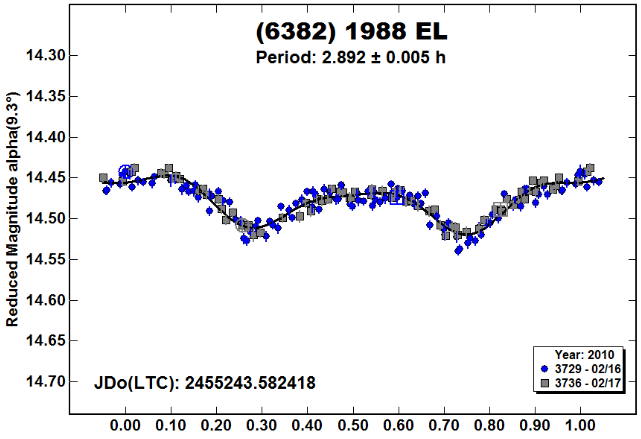

1364 Safara
Period: 7.25 ± 0.05 h
Reduced Magnitude alpha(10.9°)
11.00
11.10
11.20
11.30
11.40
11.50
11.60
11.70
11.80
JDo(LTC): 2455251.580119
Year: 2010
3743 - 02/24
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

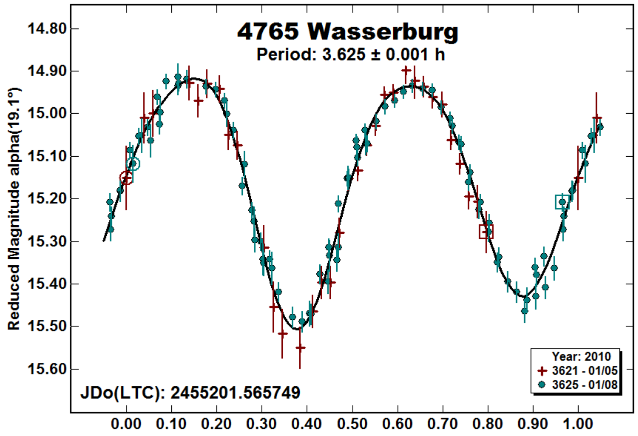

4868 Knushevia
Period: 4.54 ± 0.01 h
Reduced Magnitude alpha(6.3°)
15.10
15.15
15.20
15.25
15.30
15.35
15.40
15.45
15.50
JDo(LTC): 2455267.643850
Year: 2010
3770 - 03/12
3775 - 03/13
3779 - 03/16
3785 - 03/17
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

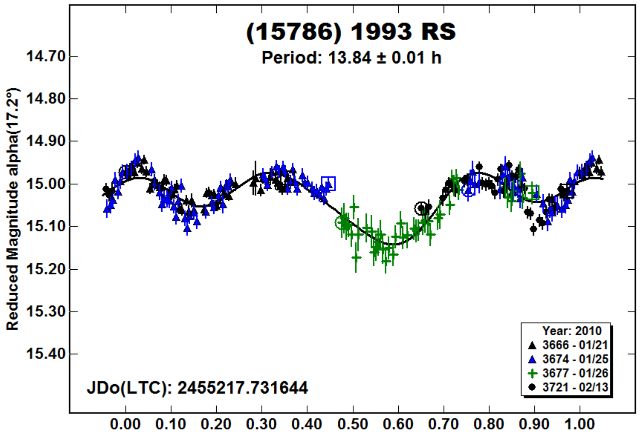

3986 Rozhkovskij
Period: 3.548 ± 0.002 h
Reduced Magnitude alpha(15.3°)
12.40
12.50
12.60
12.70
12.80
12.90
13.00
13.10
JDo(LTC): 2455197.551532
Year: 2010
3614 - 01/01
3618 - 01/03
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

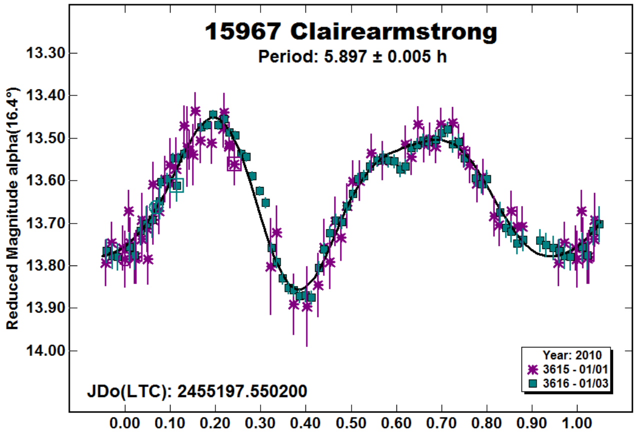

5967 Edithlevy
Period: 66 ± 1 h
Reduced Magnitude alpha(4.1°)
13.70
13.80
13.90
14.00
14.10
14.20
14.30
14.40
14.50
14.60
JDo(LTC): 2455230.708747
Year: 2010
3700 - 02/03
3704 - 02/05
3714 - 02/11
3722 - 02/13
3726 - 02/15
3731 - 02/16
3737 - 02/17
3740 - 02/23
3745 - 02/24
3750 - 03/02
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

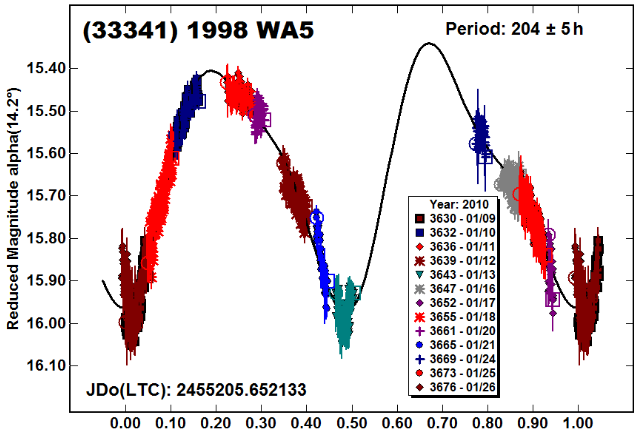

4764 Joneberhart
Period: 5.485 ± 0.003 h
Reduced Magnitude alpha(12.3°)
14.20
14.30
14.40
14.50
14.60
14.70
14.80
14.90
15.00
15.10
15.20
15.30
JDo(LTC): 2455261.592471
Year: 2010
3763 - 03/06
3769 - 03/12
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

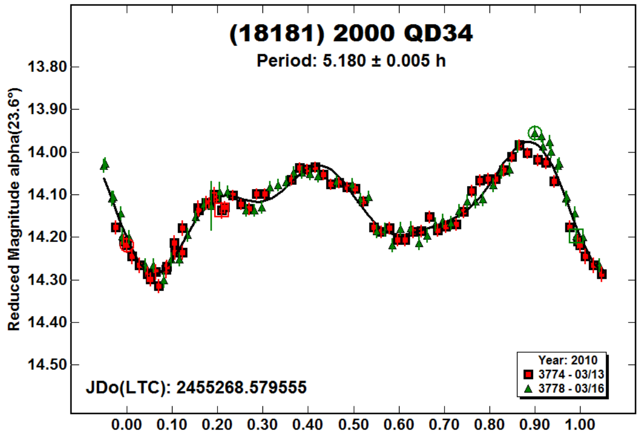

(6382) 1988 EL
Period: 2.892 ± 0.005 h
Reduced Magnitude alpha(9.3°)
14.30
14.35
14.40
14.45
14.50
14.55
14.60
14.65
14.70
JDo(LTC): 2455243.582418
Year: 2010
3729 - 02/16
3736 - 02/17
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

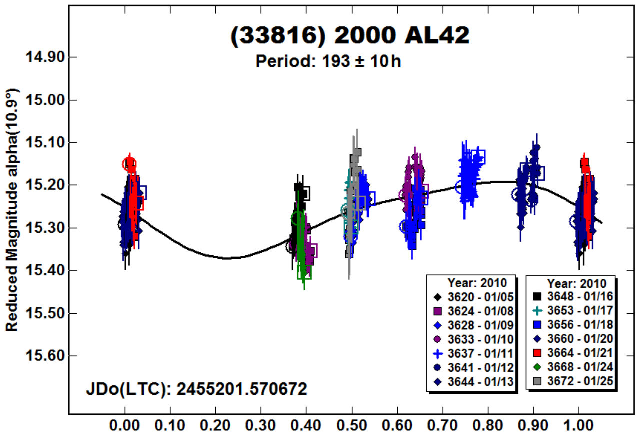

4765 Wasserburg
Period: 3.625 ± 0.001 h
Reduced Magnitude alpha(19.1°)
14.80
14.90
15.00
15.10
15.20
15.30
15.40
15.50
15.60
JDo(LTC): 2455201.565749
Year: 2010
3621 - 01/05
3625 - 01/08
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

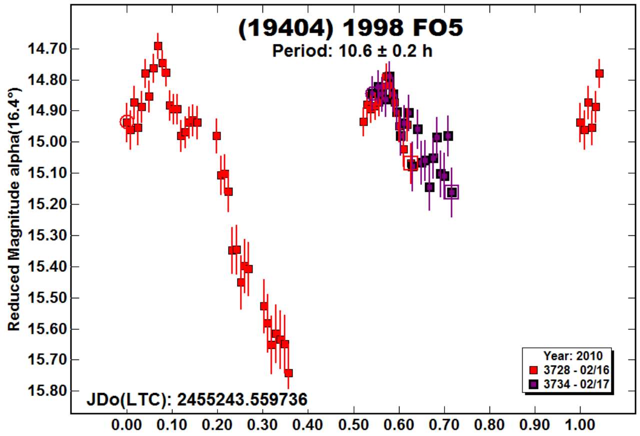

(15786) 1993 RS
Period: 13.84 ± 0.01 h
Reduced Magnitude alpha(17.2°)
14.70
14.80
14.90
15.00
15.10
15.20
15.30
15.40
JDo(LTC): 2455217.731644
Year: 2010
3666 - 01/21
3674 - 01/25
3677 - 01/26
3721 - 02/13
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

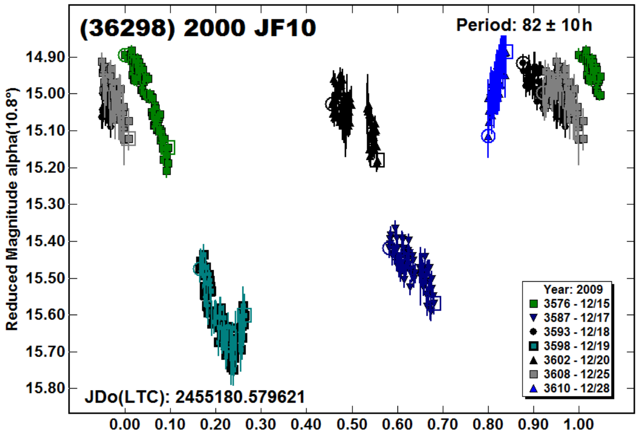

15967 Clairearmstrong
Period: 5.897 ± 0.005 h
Reduced Magnitude alpha(16.4°)
13.30
13.40
13.50
13.60
13.70
13.80
13.90
14.00
JDo(LTC): 2455197.550200
Year: 2010
3615 - 01/01
3616 - 01/03
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

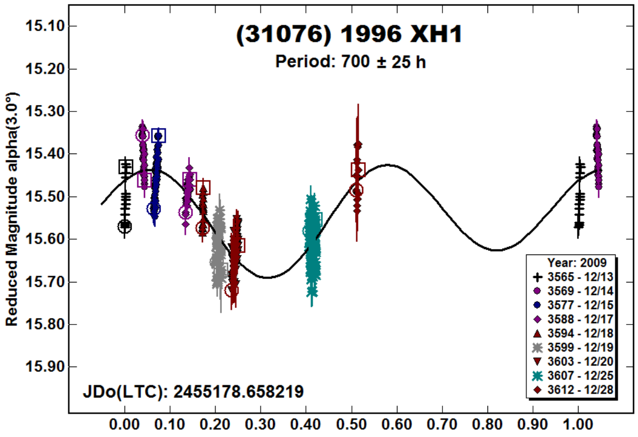

(33341) 1998 WA5
Period: 204 ± 5 h
Reduced Magnitude alpha(14.2°)
15.40
15.50
15.60
15.70
15.80
15.90
16.00
16.10
JDo(LTC): 2455205.652133
Year: 2010
3630 - 01/09
3632 - 01/10
3636 - 01/11
3639 - 01/12
3643 - 01/13
3647 - 01/16
3652 - 01/17
3655 - 01/18
3661 - 01/20
3665 - 01/21
3669 - 01/24
3673 - 01/25
3676 - 01/26
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

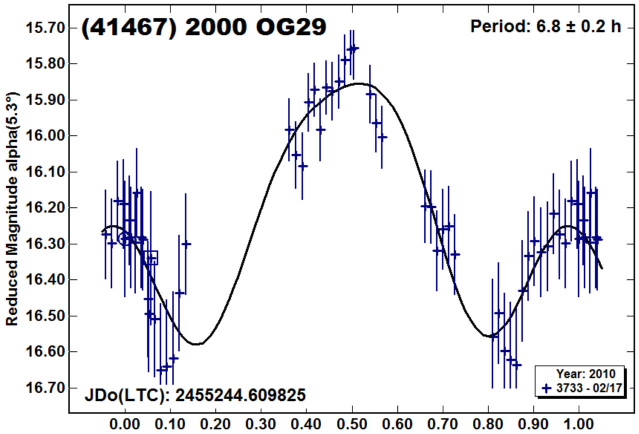

(18181) 2000 QD34
Period: 5.180 ± 0.005 h
Reduced Magnitude alpha(23.6°)
13.80
13.90
14.00
14.10
14.20
14.30
14.40
14.50
JDo(LTC): 2455268.579555
Year: 2010
3774 - 03/13
3778 - 03/16
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

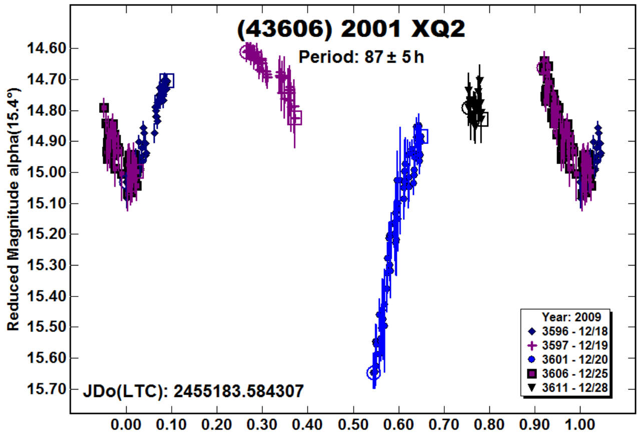

(33816) 2000 AL42
Period: 193 ± 10h
Reduced Magnitude alpha(10.9°)
14.90
15.00
15.10
15.20
15.30
15.40
15.50
15.60
JDo(LTC): 2455201.570672
Year: 2010
3620 - 01/05
3624 - 01/08
3628 - 01/09
3633 - 01/10
3637 - 01/11
3641 - 01/12
3644 - 01/13
Year: 2010
3648 - 01/16
3653 - 01/17
3656 - 01/18
3660 - 01/20
3664 - 01/21
3668 - 01/24
3672 - 01/25
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

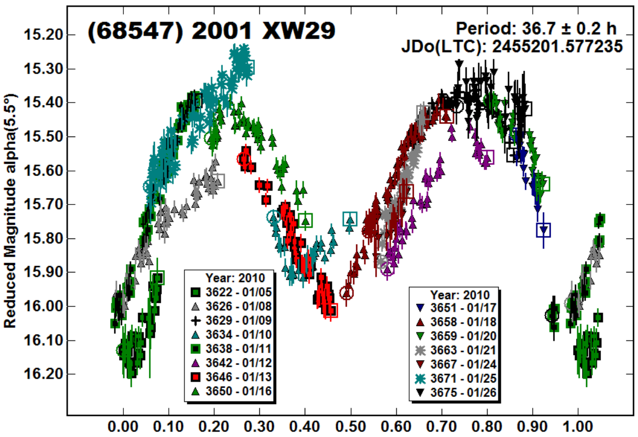

(19404) 1998 FO5
Period: 10.6 ± 0.2 h
Reduced Magnitude alpha(16.4°)
14.70
14.80
14.90
15.00
15.10
15.20
15.30
15.40
15.50
15.60
15.70
15.80
JDo(LTC): 2455243.559736
Year: 2010
3728 - 02/16
3734 - 02/17
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

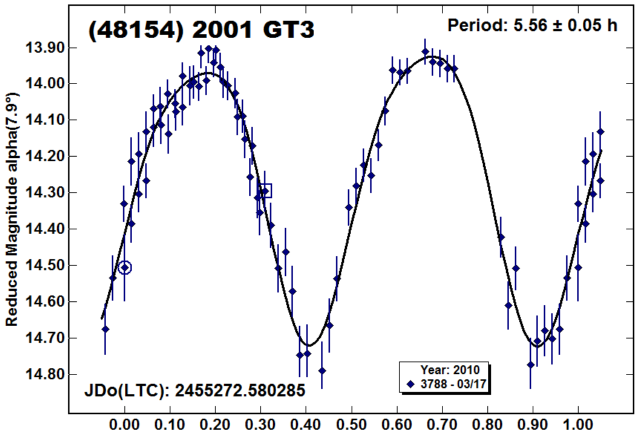

(36298) 2000 JF10
Period: 82 ± 10h
Reduced Magnitude alpha(10.8°)
14.90
15.00
15.10
15.20
15.30
15.40
15.50
15.60
15.70
15.80
JDo(LTC): 2455180.579621
Year: 2009
3576 - 12/15
3587 - 12/17
3593 - 12/18
3598 - 12/19
3602 - 12/20
3608 - 12/25
3610 - 12/28
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

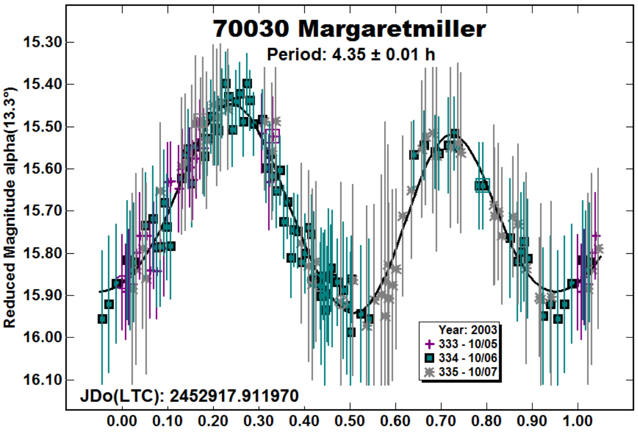

(31076) 1996 XH1
Period: 700 ± 25 h
Reduced Magnitude alpha(3.0°)
15.10
15.20
15.30
15.40
15.50
15.60
15.70
15.80
15.90
JDo(LTC): 2455178.658219
Year: 2009
3565 - 12/13
3569 - 12/14
3577 - 12/15
3588 - 12/17
3594 - 12/18
3599 - 12/19
3603 - 12/20
3607 - 12/25
3612 - 12/28
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

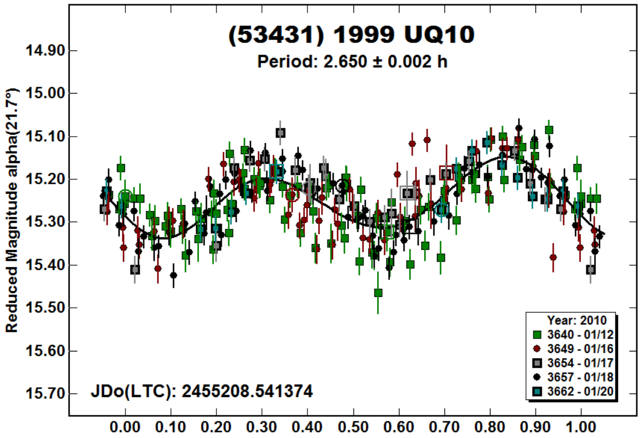

(41467) 2000 OG29
Period: 6.8 ± 0.2 h
Reduced Magnitude alpha(5.3°)
15.70
15.80
15.90
16.00
16.10
16.20
16.30
16.40
16.50
16.60
16.70
JDo(LTC): 2455244.609825
Year: 2010
3733 - 02/17
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

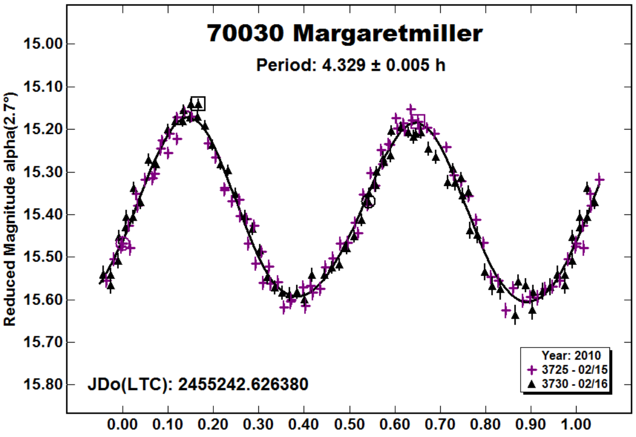

(43606) 2001 XQ2
Period: 87 ± 5 h
JDo(LTC): 2455183.584307
Reduced Magnitude alpha(15.4°)
14.60 14.70 14.80 14.90 15.00 15.10 15.20 15.30 15.40 15.50 15.60 15.70
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2009
3596 - 12/18
3597 - 12/19
3601 - 12/20
3606 - 12/25
3611 - 12/28


(68547) 2001 XW29
Period: 36.7 ± 0.2 h
JDo(LTC): 2455201.577235
Reduced Magnitude alpha(5.5°)
15.20 15.30 15.40 15.50 15.60 15.70 15.80 15.90 16.00 16.10 16.20
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
3622 - 01/05
3626 - 01/08
3629 - 01/09
3634 - 01/10
3638 - 01/11
3642 - 01/12
3646 - 01/13
3650 - 01/16
Year: 2010
3651 - 01/17
3658 - 01/18
3659 - 01/20
3663 - 01/21
3667 - 01/24
3671 - 01/25
3675 - 01/26


(48154) 2001 GT3
Period: 5.56 ± 0.05 h
JDo(LTC): 2455272.580285
Reduced Magnitude alpha(7.9°)
13.90 14.00 14.10 14.20 14.30 14.40 14.50 14.60 14.70 14.80
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
3788 - 03/17


70030 Margaretmiller
Period: 4.35 ± 0.01 h
JDo(LTC): 2452917.911970
Reduced Magnitude alpha(13.3°)
15.30 15.40 15.50 15.60 15.70 15.80 15.90 16.00 16.10
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2003
333 - 10/05
334 - 10/06
335 - 10/07


(53431) 1999 UQ10
Period: 2.650 ± 0.002 h
JDo(LTC): 2455208.541374
Reduced Magnitude alpha(21.7°)
14.90 15.00 15.10 15.20 15.30 15.40 15.50 15.60 15.70
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
3640 - 01/12
3649 - 01/16
3654 - 01/17
3657 - 01/18
3662 - 01/20


70030 Margaretmiller
Period: 4.329 ± 0.005 h
JDo(LTC): 2455242.626380
Reduced Magnitude alpha(2.7°)
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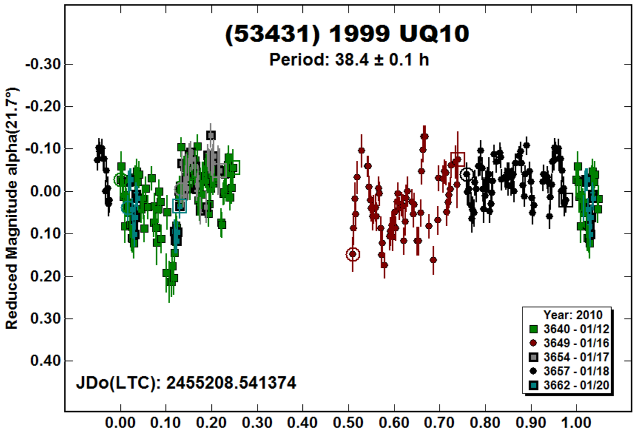
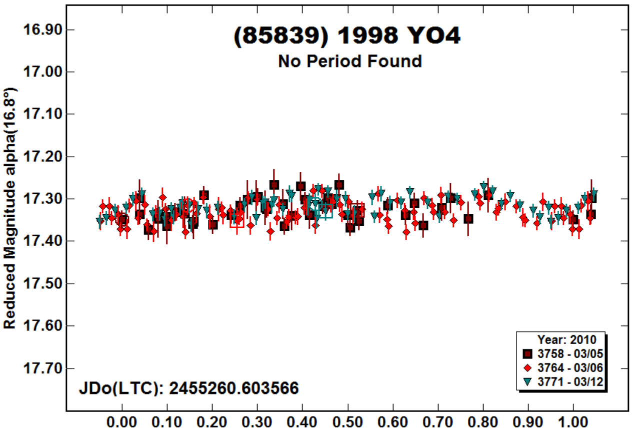
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
3725 - 02/15
3730 - 02/16


(53431) 1999 UQ10
Period: 38.4 ± 0.1 h
JDo(LTC): 2455208.541374
Reduced Magnitude alpha(21.7°)
-0.30 -0.20 -0.10 0.00 0.10 0.20 0.30 0.40
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
3640 - 01/12
3649 - 01/16
3654 - 01/17
3657 - 01/18
3662 - 01/20


(85839) 1998 YO4
No Period Found
JDo(LTC): 2455260.603566
Reduced Magnitude alpha(16.8°)
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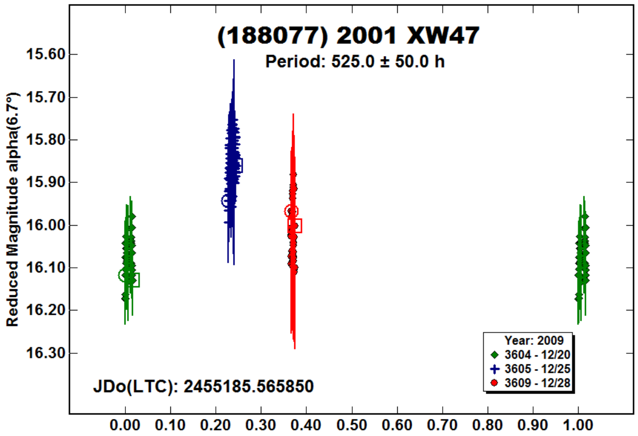
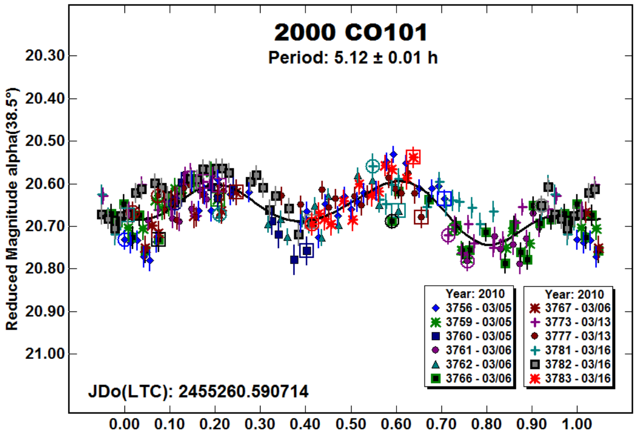
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
3758 - 03/05
3764 - 03/06
3771 - 03/12





| # | Name | mm/dd 2010 | Data Pts | α | $L_{PAB}$ | $B_{PAB}$ | Per (h) | PE | Amp (mag) | AE |
|---|---|---|---|---|---|---|---|---|---|---|
| 205 | Martha | 01/30-02/11 | 313 | 19.0,20.4 | 76 | -10 | 39.8 | 0.1 | 0.50 | 0.03 |
| 379 | Huenna | 01/30-02/11 | 206 | 18.0,18.8 | 80 | -2 | 14.14 | 0.01 | 0.07 | 0.01 |
| 456 | Abnoba | 01/01-01/08 | 303 | 9.3,11.2 | 74 | -9 | 18.273 | 0.005 | 0.27 | 0.01 |
| 479 | Caprera | 01/30-02/02 | 266 | 15.4,16.4 | 99 | -5 | 9.43 | 0.02 | 0.12 | 0.01 |
| 616 | Elly | 01/30-02/01 | 135 | 15.0,14.3 | 162 | 7 | 5.297 | 0.003 | 0.44 | 0.02 |
| 766 | Moguntia | 01/30-02/11 | 173 | 13.1,9.4 | 166 | 6 | 4.818 | 0.002 | 0.08 | 0.01 |
| 1069 | Planckia | 01/30-02/02 | 219 | 11.4,12.2 | 200 | -10 | 8.665 | 0.005 | 0.42 | 0.02 |
| 1364 | Safara | 02/24 | 106 | 10.7 | 126 | 12 | 7.25 | 0.05 | 0.36 | 0.02 |
| 3986 | Rozhkovskij | 01/01-01/03 | 149 | 14.5,15.6 | 78 | 2 | 3.548 | 0.002 | 0.34 | 0.02 |
| 4764 | Joneberhart (H) | 03/06-03/12 | 201 | 12.2,13.5 | 164 | 20 | 5.485 | 0.003 | 0.96 | 0.02 |
| 4765 | Wasserburg (H) | 01/05-01/08 | 118 | 19.3,18.8 | 124 | 24 | 3.625 | 0.001 | 0.60 | 0.02 |
| 4868 | Knushevia (H) | 03/12-03/17 | 134 | 6.3,6.6 | 171 | -9 | 4.54 | 0.01 | 0.08 | 0.01 |
| 5967 | Edithlevy (H) | 02/03-03/02 | 753 | 3.9,18.5 | 135 | 9 | 66 (NPAR) |  | 0.7 | 0.05 |
| 6382 | 1988 EL (H) | 02/16-02/17 | 170 | 9.5,9.3 | 148 | 12 | 2.892 | 0.005 | 0.07 | 0.01 |
| 15786 | 1996 RS (H) | 01/21-02/13 | 241 | 17.6,14.6 | 134 | 22 | 13.84 | 0.01 | 0.21 | 0.02 |
| 15967 | Clairearmstrong | 01/01-01/03 | 137 | 15.9,16.6 | 76 | -11 | 5.897 | 0.005 | 0.41 | 0.02 |
| 18181 | 2000 QD34 | 03/13-03/16 | 116 | 23.5,24.5 | 129 | 5 | 5.180 | 0.005 | 0.32 | 0.02 |
| 19404 | 1998 FO5 | 02/16-02/17 | 76 | 15.9,16.2 | 109 | -2 | 10.6 | 0.2 | 0.80 | 0.05 |
| 31076 | 1996 XH1 (H) | 12/13-12/28[1] | 329 | 3.3,10.7 | 84 | 5 | 700/350 | 25 | 0.17 | 0.03 |
| 33341 | 1998 WA5 (H) | 01/09-01/26 | 1016 | 14.4,13.6,15.1 | 121 | 18 | 204 | 5 | 0.57 | 0.05 |
| 33816 | 2000 AL42(H) | 01/05-01/25 | 391 | 10.3,19.9 | 92 | -6 | 193/390 | 10 | 0.12 | 0.01 |
| 36298 | 2000 JF10(H) | 12/15-12/28[1] | 427 | 10.4,15.5 | 76 | -11 | 82 (NPAR) | 10 | 0.75 | 0.05 |
| 41467 | 2000 OG29 | 02/17 | 52 | 4.9 | 142 | -8 | 6.8/10.0/14.5 | 0.2 | 0.8 | 0.05 |
| 43606 | 2001 XQ2(H) | 12/18-12/28[1] | 253 | 15.0,17.8 | 74 | 20 | 87 (NPAR?) | 5 | 1.3 | 0.2 |
| 48154 | 2001 GT3 | 03/17 | 70 | 7.7 | 161 | 11 | 5.56 | 0.05 | 0.79 | 0.02 |
| 53431 | 1999 UQ10(H) | 01/12-01/20 | 335 | 21.4,22.9 | 94 | 32 | 2.650 + 38.4 | 0.002 | 0.15 | 0.02 |
| 68547 | 2001 XW29(H) | 01/05-01/26 | 630 | 5.5,15.5 | 108 | -8 | 36.7 (NPAR) | 0.2 | 0.60 | 0.05 |
| 70030 | Margaretmiller(H) | 10/05-10/07[2] | 157 | 13.3,13.2 | 17 | 21 | 4.35 | 0.01 | 0.50 | 0.03 |
| 70030 | Margaretmiller(H) | 02/15-02/16 | 157 | 2.1,2.5 | 146 | -3 | 4.329 | 0.005 | 0.41 | 0.02 |
| 85839 | 1998 YO4 | 03/05-03/12 | 185 | 16.7,19.7 | 158 | 14 | - |  | <0.05 |  |
| 188077 | 2001 XW47(H) | 12/20-12/28[1] | 145 | 5.7,11.5 | 80 | 1 | 525 | 50 | 0.27 | 0.03 |
|  | 2000 CO101 | 03/05-03/16 | 222 | 38.5,37.2,37.6 | 148 | 12 | 5.12 | 0.01 | 0.10 | 0.01 |

[1] 2009 observations
[2] 2003 observations

Table I. Observing circumstances. Asteroids with "(H)" after the name are members of the Hungaria group. The phase angle is given at the start and end of each date range, unless it reached a minimum, which is then the second of three values. If a single value is given, the phase angle did not change significantly and the average value is given. $L_{PAB}$ and $B_{PAB}$ are each the average phase angle bisector longitude and latitude, unless two values are given (first/last date in range).

# PERIOD DETERMINATIONS FOR 11 PARTHENOPE, 35 LEUKOTHEA, 38 LEDA, 111 ATE, 194 PROKNE, 262 VALDA, 728 LEONISIS, AND 747 WINCHESTER

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(Received: 25 March)

Synodic rotation periods and amplitudes have been found for these asteroids: 11 Parthenope 13.722 ± 0.001 h, 0.11 ± 0.01 mag with one maximum and minimum per cycle; 35 Leukothea 31.900 ± 0.001 h, 0.42 ± 0.04 mag; 38 Leda 12.839 ± 0.001 h, 0.14 ± 0.02 mag, 111 Ate 22.072 ± 0.002 h, 0.09 ± 0.02 mag with an irregular lightcurve; 194 Prokne 15.677 ± 0.002 h, 0.08 ± 0.01 mag with one maximum and minimum per cycle; 262 Valda 17.386 ± 0.001 h, 0.17 ± 0.02 mag; 728 Leonisis 5.5783 ± 0.0002 h, 0.20 ± 0.04 mag; 747 Winchester 9.414 ± 0.001h, 0.18 ± 0.02 mag.

These reported observations were all obtained at the Organ Mesa Observatory. Equipment consists of a 35.4 cm Meade LX 200 GPS S-C and SBIG STL-1001E CCD, with unguided exposures through an R filter for 11 Parthenope and 111 Ate and clear filter for other targets, differential photometry only. Image measurement and lightcurve analysis were done with *MPO Canopus*. The lightcurves have been drawn with the large number of data points acquired for each target in this study binned in sets of three with a maximum of five minutes between points.

11 Parthenope. Until very recently every attempt at rotation period determination has produced a different result. All show low amplitude and complex lightcurves, for which alias periods are especially troublesome. In chronological sequence van Houten-Groeneveld and van Houten (1958) obtained an indefinite 10.7 hour period and 0.07 magnitude amplitude. Wood and Kuiper (1963) published an amplitude 0.12 magnitude and no period determination. Zappala (1983) obtained amplitude exceeding 0.07 mag and no period determination. Barucci et. al. (1985) found a period 7.83 hours, amplitude 0.08 mag. Melillo (1985) suggested a possible 5 hour period and 0.08 mag amplitude. Lang (1996) found amplitude 0.05 mag and possible period 11.75 hours. Piironen et. al. (1998) obtained a bimodal lightcurve of period 9.43 hours, amplitude 0.05 mag. Lang and Hansen (1999) obtained the first dense data set. It shows one narrow and one broad maximum, amplitude 0.10 mag, for which they claim a search of all possible periods from 5 hours to 2.3 days produced only one low residual fit at 13.720 hours. They also claim evidence for prograde rotation. Stephens et. al. (2008) obtained a period of 13.734 hours.

New observations at the Organ Mesa Observatory on 8 nights 2009 Nov. 28 – 2010 Jan. 17 show an irregular monomodal lightcurve with period 13.722 ± 0.001 hours, amplitude 0.11 ± 0.01 magnitudes. This is fully compatible with the dense data sets of Lang and Hansen (1999) and Stephens et. al. (2008). A period near 13.72 hours now seems to be well established.

35 Leukothea. All previous observations are consistent with a rotation period near 31.9 hours, and with greatly varying amplitude. Weidenschilling et. al. (1990) at longitude 87 degrees observed an amplitude of 0.38 magnitudes. Pilcher (2008) obtained at longitudes 357 – 347 degrees an amplitude 0.07 ± 0.02 magnitudes. Lagerkvist et. al. (1987) show no variation beyond 0.02 magnitude scatter in a one hour run at longitude 249 degrees. Bernasconi, as presented by Behrend, (2008) obtained amplitude 0.38 ± 0.03 magnitudes near longitude 135 degrees. Pilcher and Jardine (2009) obtained near longitude 42 degrees an amplitude 0.08 ± 0.02 magnitudes. From a comparison of these amplitudes and the longitudes at which they were observed they concluded that a rotational pole was near longitude 17 degrees, latitude 0 degrees. The January, 2010 opposition at longitude 117 degrees provided an opportunity to obtain lightcurves at near equatorial aspect with obliquity near 90 degrees. Under this circumstance synodic and sidereal periods are nearly the same. Both of the previous data sets at near equatorial aspect covered only a short observation interval. This investigation on 10 nights over an interval of 75 days 2009 Dec. 3 – 2010 Feb. 16 obtains a synodic period 31.900 ± 0.001 hours, amplitude 0.42 ± 0.04 magnitudes. This is much closer to the sidereal rotation period than has been obtained with any previous study. The ratio a/b of maximum to minimum equatorial radii is found from a/b >=10^(0.4Delta Mag). For Delta Mag = 0.42 in the 2010 near equatorial aspect, a/b for 35 Leukothea is approximately 1.47. The ratio of minimum equatorial to polar radii b/c cannot be found from any data yet available.

Future studies. The rotation period is now known with sufficient accuracy to extrapolate the phase of any observation throughout any apparition. The rotational pole, as is commonly the case, has a bivalued solution, either longitude 17 degrees or 197 degrees. The next three oppositions, 2011 May 27, 2012 Sept. 3, 2013 Oct. 29, all occur fairly close to polar aspect. If at any of these there can be two moderately well observed occultations separated in time by an interval not close to an integer, half integer, or quarter integer number of rotational cycles, the change in orientation of the long axis will resolve the ambiguity of pole position. Alternatively, this goal can be achieved with disk resolved adaptive optics.

38 Leda. Previous period determinations are by De Young and Schmidt (1996), 12.84 hours; Wang and Shi (2002), 10.171 hours; and Pilcher (2009), 12.838 hours. New observations were made on 3 nights 2009 Nov. 19, 2010 Jan. 4, 9. Being few in number and widely separated in time, the data can be phased to several different periods with comparably good fit. Hence this investigation does not provide an independent period determination. The shortest of these periods, 12.839 ± 0.001 hours with amplitude 0.14 ± 0.02 magnitudes, is compatible with De Young and Schmidt (1996) and Pilcher (2009). The accompanying lightcurve is phased to this period. As is usually the case, there is considerable change in shape with greatly changing phase angle.

111 Ate. The only previous lightcurves are by Harris and Young (1983) who state a period 22.2 hours. New observations on 9 nights 2009 Nov. 21 – 2010 Jan. 16 show a period 22.072 ± 0.002 hours, amplitude 0.09 ± 0.02 magnitudes. An irregular lightcurve changed shape appreciably during the observation interval but the phases of the principal features remained nearly constant.

194 Prokne. Scaltriti and Zappala (1979) obtained absolute photometry at longitude 245 degrees, latitude +31 degrees, which included two well defined minima. No maximum was covered, but the amplitude is unlikely to be much larger than the maximum observed 0.27 magnitudes. They phased their data to a rotation period of 15.67 hours based on 60% coverage of a presumed bimodal lightcurve. New observations were obtained on 9 nights 2010 Jan. 30 – Mar. 19 at longitudes 174 to 164 degrees showing an amplitude only 0.08 ±0.01 magnitudes. The most likely

interpretation is of a period 15.677 ± 0.002 hours with one maximum and minimum per cycle at a near polar aspect, and the accompanying lightcurve is phased to this period. This would imply the observations of Scaltriti and Zappala (1979) were at near equatorial aspect. The new observations and theirs constitute a consistent rotation model with a well defined period and approximate pole orientation within 30 degrees of longitude 170 degrees, latitude 2 degrees. The new data were also phased to periods two and three times as great with 2 and 3, respectively, maxima and minima per cycle. The multiple extrema on these had similar but not identical appearances. I consider these differences are very likely due to instrumental anomalies up to 0.02 magnitudes which are more prominent at low amplitude and to variations in the appearance of the lightcurve with greatly changing phase angle, rather to rotation periods of 31.356 or 47.039 hours. Furthermore the data of Scaltriti and Zappala (1979) can be phased to 31.356 or 47.039 hours only if their resulting lightcurve has four or six, respectively, maxima and minima per cycle. Their 0.27 magnitude amplitude seems unrealistically large for a lightcurve with such a large number of extrema per cycle.

262 Valda. The Asteroid Lightcurve Data Base (Harris et. al. 2009) shows no previous observations. Observations on 9 nights 2010 Jan. 24 – Mar. 4 show a period 17.386 ± 0.001 hours, amplitude 0.17 ± 0.02 magnitudes.

728 Leonisis. The Asteroid Lightcurve Data Base (Harris et. al. 2009) shows no previous observations. Observations on 6 nights 2009 Dec. 27 – 2010 Feb. 1 show a period 5.5783 ± 0.0002 hours, amplitude 0.20 ± 0.04 magnitudes.

747 Winchester. The Asteroid Lightcurve Data Base (Harris et. al. 2009) shows period 9.4146 hours, reliability 3 (secure). Additional lightcurves were obtained to contribute toward a spin/shape model. Observations on 4 nights 2008 May 9 – 26 show a period 9.414 ± 0.001 hours, amplitude 0.18 ± 0.02 magnitudes, consistent with previous work.

Acknowledgments. The author expresses his thanks to A. Harris (2010) who provided helpful advice in the analysis of observations for 194 Prokne, and to P. Pravec (2010) who provided helpful advice in the analysis of observations for 111 Ate and 262 Valda.

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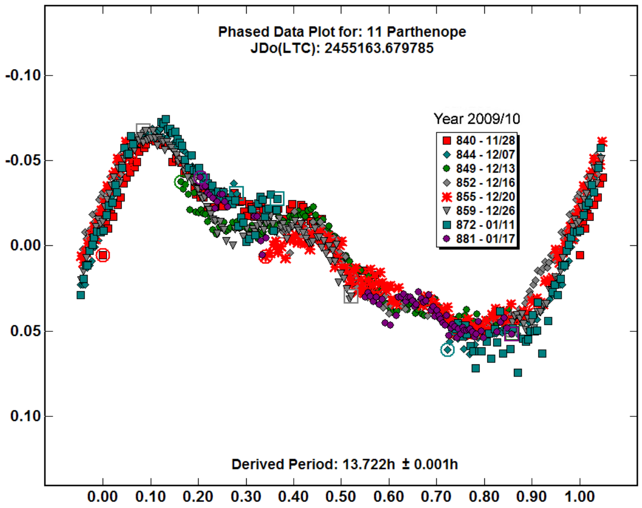
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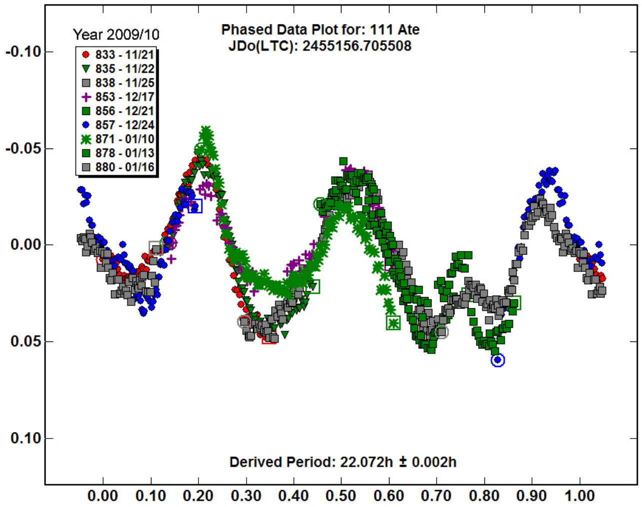
849 - 12/13
852 - 12/16
855 - 12/20
859 - 12/26
872 - 01/11
881 - 01/17
-0.10
-0.05
0.00
0.05
0.10
Derived Period: 13.722h ± 0.001h
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00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838 - 11/25
853 - 12/17
856 - 12/21
857 - 12/24
871 - 01/10
878 - 01/13
880 - 01/16
-0.10
-0.05
0.00
0.05
0.10
Derived Period: 22.072h ± 0.002h
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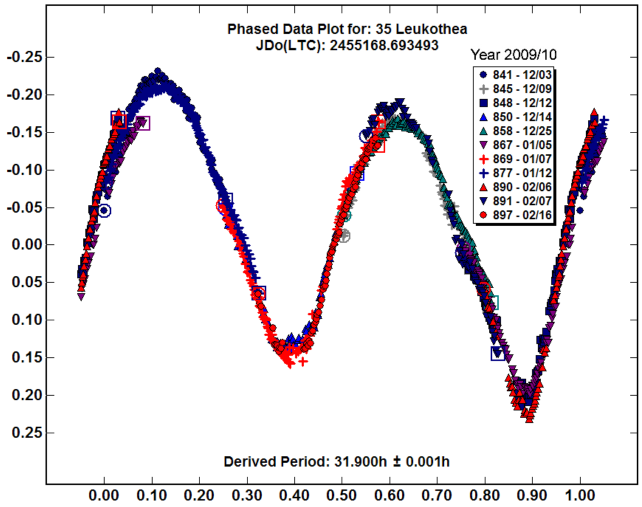
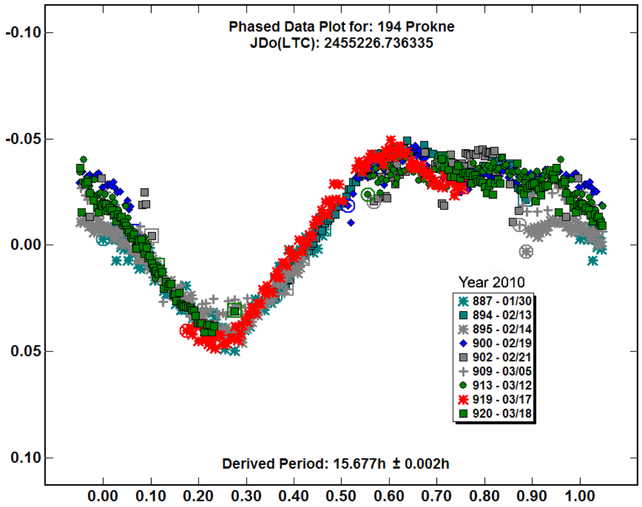
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


Phased Data Plot for: 35 Leukothea
JDo(LTC): 2455168.693493
Year 2009/10
841 - 12/03
845 - 12/09
848 - 12/12
850 - 12/14
858 - 12/25
867 - 01/05
869 - 01/07
877 - 01/12
890 - 02/06
891 - 02/07
897 - 02/16
-0.25
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
Derived Period: 31.900h ± 0.001h
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00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Year 2010
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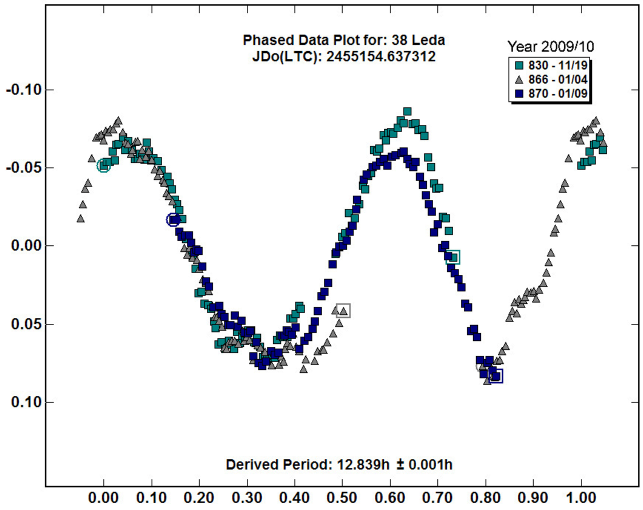
895 - 02/14
900 - 02/19
902 - 02/21
909 - 03/05
913 - 03/12
919 - 03/17
920 - 03/18
-0.10
-0.05
0.00
0.05
0.10
Derived Period: 15.677h ± 0.002h
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00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Year 2009/10
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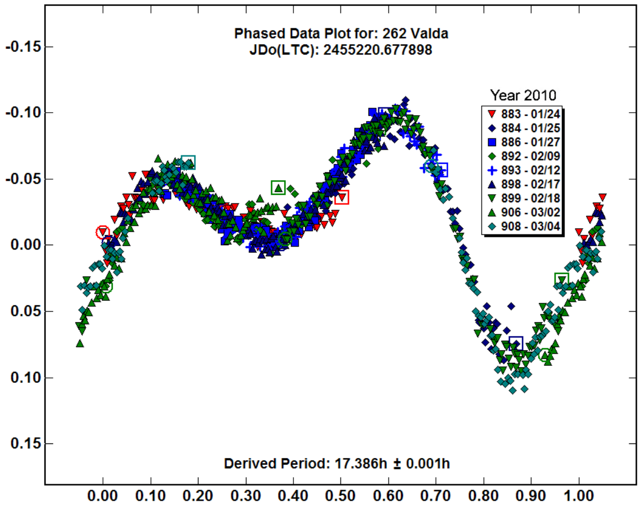
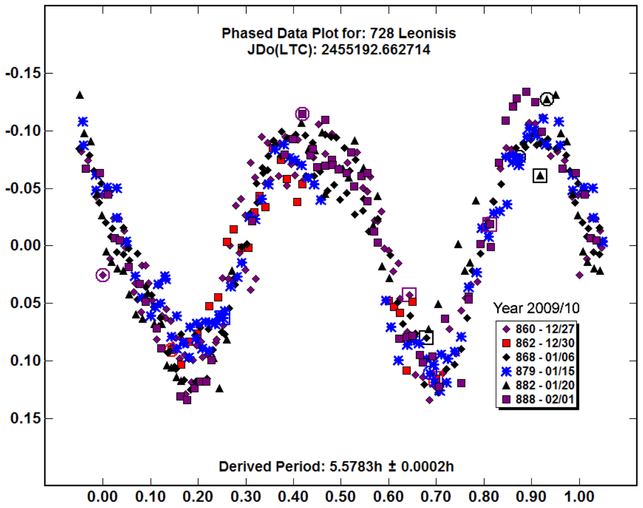
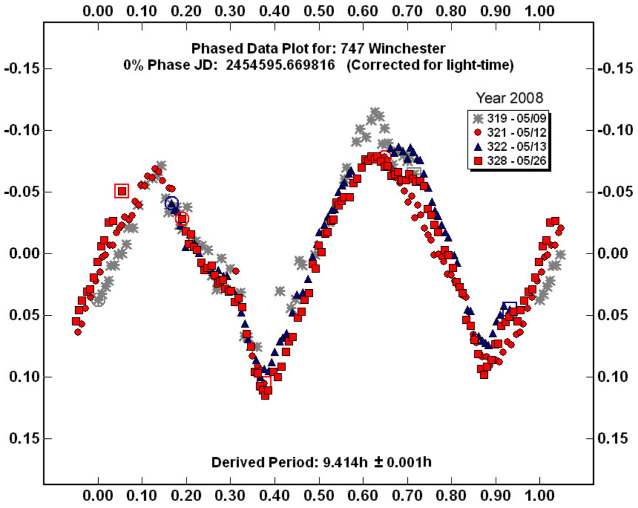
866 - 01/04
870 - 01/09
-0.10
-0.05
0.00
0.05
0.10
Derived Period: 12.839h ± 0.001h
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


Phased Data Plot for: 262 Valda
JDo(LTC): 2455220.677898
Year 2010
883 - 01/24
884 - 01/25
886 - 01/27
892 - 02/09
893 - 02/12
898 - 02/17
899 - 02/18
906 - 03/02
908 - 03/04
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
Derived Period: 17.386h ± 0.001h
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00





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# LIGHTCURVE ANALYSIS OF 581 TAUNTONIA, 776 BERBERICIA AND 968 PETUNIA

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(Received: 2 April)

Results from Santana and GMARS Observatories over 2009 December to 2010 March are presented: 581 Tuantonia, P=24.90 ± 0.01 h, A=0.20 mag.; 776 Berbericia, P=7.67 ± 0.01 h, A=0.12 mag.; 968 Pentunia, P=61.280 ± 0.005 h, A=0.40 mag.

Unfiltered observations were made at Santana Observatory (MPC Code 646) were made with a 0.30-m Schmidt-Cassegrain (SCT) with a SBIG STL-1001E. Observations at GMARS (Goat Mountain Astronomical Research Station, MPC G79) were made with two telescopes, both 0.35-m SCT using SBIG STL-1001E CCD Cameras. All images were unguided and unbinned. Measurements were made using *MPO Canopus*, which employs differential aperture photometry to produce the raw data. Period analysis was done using *Canopus*, which incorporates the Fourier analysis algorithm (FALC; Harris 1989). Unless noted, the asteroids were selected from the list of asteroid photometry opportunities published on the Collaborative Asteroid Lightcurve Link (CALL) website (Warner et al. 2009).

The results are summarized in Table I, as are individual plots. The plots are "phased", i.e., they range from 0.0 to 1.0 of the stated period. The plots are scaled such that 1.0 mag has the same linear size as the horizontal axis from 0.0 to 1.0. This is done to avoid the visual impression that the amplitude variation is greater than it actually is, which can create the impression of a physically implausible lightcurve. Night-to-night calibration of the data (generally < ±0.05 mag) was done using field stars converted to approximate Cousins R magnitudes based on 2MASS J-K colors (Warner 2007 and Stephens 2008).

581 Tauntonia. Observations were made on six nights spanning three weeks. Observations on 01/08, 01/11, and 01/24 were obtained at Santana Observatory. All others were taken at GMARS. Behrend (2010) reported a single night of observations in June 2006 by Rene Roy with a period of 16.19 hours.

776 Berbericia. Berbericia is a well studied object selected as a Full Moon project to provide observations for additional future shape-model study. Durech et al. (2007) previously reported a shape model based upon observations from 1977 - 2006 while determining the period to be 7.66701 h.

968 Petunia. Wisniewski (1997) got a single night lightcurve fragment in 1992 but did not report a period. Behrend (2010) reported a single night of observations in April 2006 by Roberto Crippa with a period of approximately 10 hours. The observations on 12/19 and 01/03 were obtained at GMARS. All others were taken at Santana Observatory.

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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.

| | 581 Tuantonia | 776 Berbericia | 968 Pentunia |
|---|---|---|---|
| Dates | 2010/01/08 – 01/31 | 2010/03/29 – 03/30 | 2009/12/15 – 2010/01/05 |
| Data Pts | 1140 | 573 | 1584 |
| α | 1.5, 9.5 | 8.2 | 8.8, 9.2 |
| Avg $L_{PAB}$ | 103 | 176 | 97 |
| Avg $B_{PAB}$ | 1 | 22 | -14 |
| Per. (h) | 24.90 | 7.67 | 61.280 |
| PE (h) | 0.01 | 0.01 | 0.005 |
| Amp (mag) | 0.20 | 0.12 | 0.40 |
| AE (mag) | 0.02 | 0.02 | 0.03 |

Table I. Observing circumstances.

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

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

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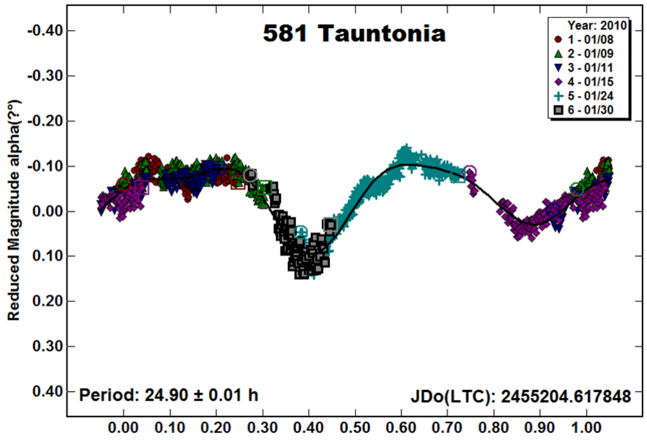

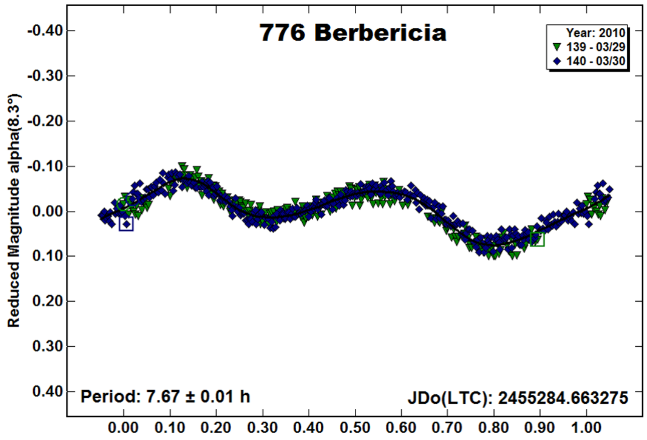

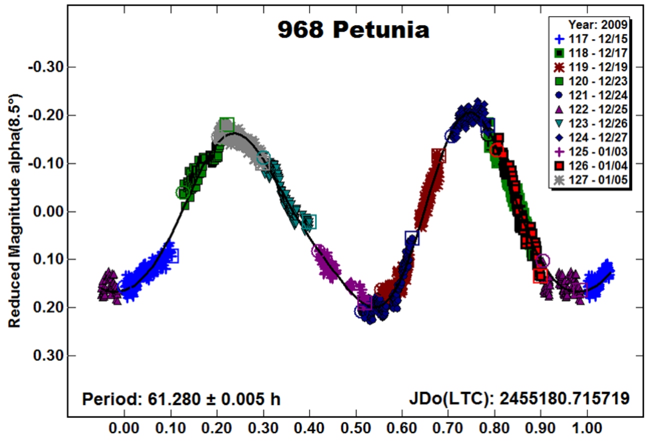

# LIGHTCURVE ANALYSIS OF 5899 JEDICKE: A NEW HUNGARIA BINARY

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CCD photometric observations of the Hungaria asteroid 5899 Jedicke obtained in 2010 February and March show that the asteroid is a binary system. The orbital period is 16.7 ± 0.1 h. The rotation period of the primary could not be determined with certainty due to the low amplitude of the lightcurve, A = 0.04 mag, but lies in the range of 3-4 h. The estimated size ratio of the pair is Ds/Dp ~ 0.32.

CCD observations of the Hungaria asteroid 5899 Jedicke were obtained at the Palmer Divide Observatory (PDO) from 2010 February 3-16 (see Warner 2010, for details about equipment and reduction and analysis methods). Analysis of the data in-hand showed what appeared to be mutual events (occultations and/or eclipses) due to a satellite and that *Porb* ~ 16.7 h. Due to the low amplitude of the primary lightcurve (*A* = 0.04 mag), it was not possible to find a unique period for the primary, though it was confined to the range of 3-4 hours.

Additional observations were obtained from 2010 February 17 through March 4 at PDO as well as by Pray at Carbuncle Hill using an f/7.8, 0.35-m Schmidt-Cassegrain (SCT) with an SBIG ST-10XE CCD operating at a scale of 1.2 arc sec/pixel and by Pollock et al. using the 0.45-m PROMPT telescope in Chile, which captured some additional events. A refined analysis of the larger data set by Pravec and Kušnirák confirmed the 16.7 h orbital period. A unique period for the primary still could not be found, though one at ~3.5 h was slightly better than most others in the 3-4 h range. (See Figure 2.) Based on the depths of the events, we estimate the size ratio (Ds/Dp) to be ≥ 0.32.

As of 2010 March 20, this brings to 12 the total number of known Hungaria binaries (“B”) with an additional 2 that are likely candidates (“?”) and 2 others that have shown weak evidence where observational issues were eliminated (“??”). The last two are included to encourage careful observations at future apparitions.

## Acknowledgements

Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNX 09AB48G, by National Science Foundation grant AST-0907650, and by a 2007 Gene Shoemaker NEO Grant from the Planetary Society. The work at Ondřejov was supported by the Grant Agency of the Czech Republic, Grant 205/09/1107. Support for PROMPT has been provided by the National Science Foundation under awards CAREER-0449001, AAG-0707634, and MRI-0836187. Work at Carbuncle Hill Observatory is supported by a Gene Shoemaker NEO Grant from the Planetary Society. This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by NASA and NSF.

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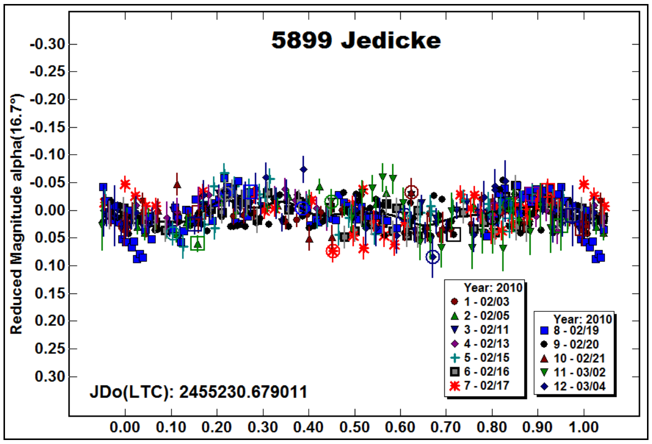

Figure 1. The short-period lightcurve for 5899. This curve is fit to ~3.5 h but several periods between 3 and 4 hours are possible.

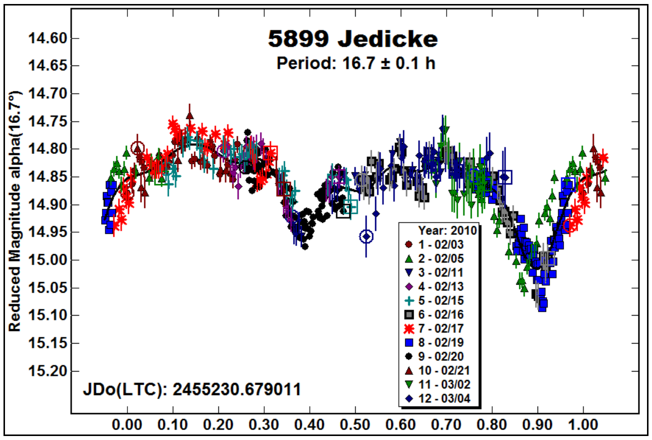

Figure 2. The long-period lightcurve for 5899 shows the mutual events, which allowed finding the orbital period.

**Known, Possible, and Suspicious Hungaria Binaries**

| Number | Name | P1 | Porb | Status |
|---|---|---|---|---|
| 1453 | Fennia | 4.412 | 22.99 | B |
| 1509 | Esclangona | 3.25 | ~900 | B |
| 2074 | Shoemaker | 2.533 | 55.5 | ? |
| 2083 | Smither | 2.672 | 30.09 | ?? |
| 2131 | Mayall | 2.568 | 23.48 | B |
| 2577 | Litva | 2.813 | 35.8 | B |
| 3309 | Brorefeld | 2.504 | 18.46 | B |
| 3873 | Roddy | 2.479 | 47.3 | ?? |
| 4674 | Pauling | 2.531 | ~3500 | B |
| 5477 | 1989 UH2 | 2.994 | 24.42 | B |
| 5899 | Jedicke | 3-4 | 16.7 | B |
| 5905 | Johnson | 3.782 | 21.78 | B |
| 6901 | Roybishop | 4.682 | 17.16 | ? |
| 9069 | Hovland | 4.218 | 30.33 | B |
| 26471 | 2000 AS152 | 2.687 | 39.25 | B |
| 76818 | 2000 RG79 | 3.166 | 14.12 | B |

Table I. A list of known and likely Hungaria binary asteroids. P1 is the approximate rotation period of the primary (in hours) and Porb is the orbital period of the satellite.

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# THE LIGHTCURVE FOR THE LONG-PERIOD ASTEROID 4024 RONAN

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(Received: 2 April)

The main-belt asteroid 4024 Ronan was observed 2010 January to March. The derived lightcurve has a synodic period of 365 ± 5 h and an amplitude of 1.0 ± 0.05 mag.

Observations of the main-belt asteroid 4024 Ronan were made by the authors from 2010 January 9 through March 13. The combined data set consists of 2868 data points. Most images were unbinned with no filter. Stephens' observations used a 0.30-m or a 0.35-m SCT with a SBIG STL-1001E CCD camera. Observations at Palmer Divide were made with a 0.35-m SCT using a SBIG STL-1001E CCD Camera. Measurements were made using *MPO Canopus*, which employs differential aperture photometry to produce the raw data. Period analysis was done using *Canopus*, which incorporates the Fourier analysis algorithm (FALC) developed by Harris et al. (1989).

Night-to-night calibration of the zero points was done using 2MASS magnitudes of up to five comparison stars of similar color to an asteroid. See Warner (2007) and Stephens (2008) for further discussion of this process that provides calibration of the nightly zero points typically good to within 0.05 magnitudes. When working long-period asteroids where a single observing session typically produces a flat curve, it is necessary to calibrate the night-to-night zero points.

4024 Ronan was previously observed by Stephens (2003), who initially found a period of 18.9 h. This analysis was done before the new calibration techniques were developed and resulted in an asymmetric and noisy lightcurve with a 0.4 mag amplitude. Since 2010 provided a favorable opposition, Stephens decided to re-observe Ronan to check the previous results. The observations produced flat lightcurve segments, often characteristic of a long-period. Even though the observing circumstances were similar to the 2003 observations, the amplitude using calibrated data was far greater. This prompted Stephens to recover and re-measure the 2003 observations using the new calibration methods. The revised results were a partial lightcurve consistent with the 2010 observations. Without calibrating the nightly zero points, a period from the 2003 data could not have been obtained.

The combination of the estimated size of 10 km and ~360 h period make the asteroid a good candidate for tumbling, or non-principal axis rotation (NPAR; see Pravec et al. 2005). However, since the conversion of the 2MASS magnitudes has errors up to ± 0.05 mag, the night-to-night calibrations have minor adjustments. For this reason we cannot say for certain whether or not Ronan is tumbling.

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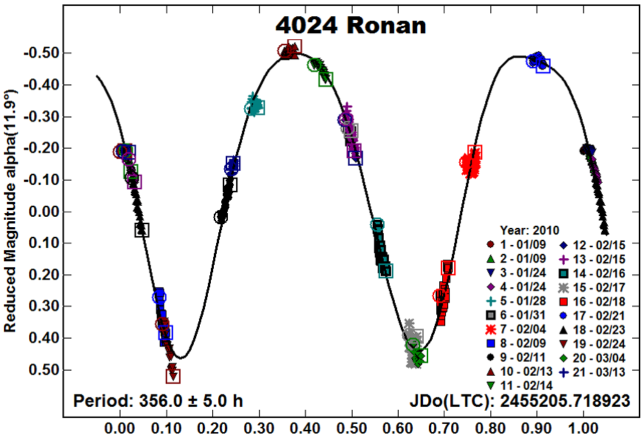

Figure 1: 2010 observations. Avg. $L_{PAB}$ = 128°, Avg. $B_{PAB}$ = 10°.

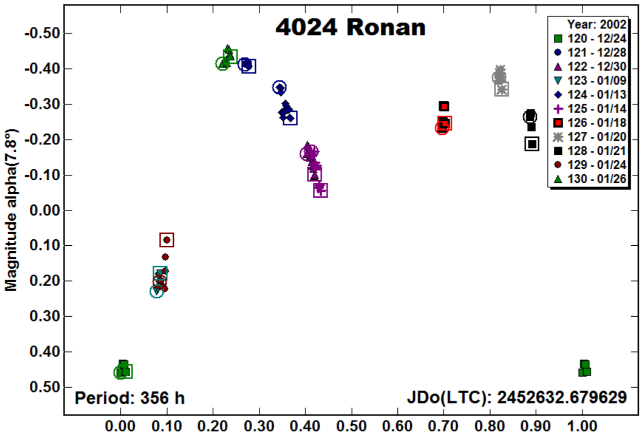

Figure 2: 2003 observations set to *P* = 356 h. Avg. $L_{PAB}$ = 90°, Avg. $B_{PAB}$ = 4°.

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# ASTEROIDS OBSERVED FROM THE SHED OF SCIENCE OBSERVATORY: 2009 OCTOBER – 2010 MARCH

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Lightcurve measurements from the Shed of Science Observatory for 2009 October to 2010 March are reported: 616 Elly, P = 5.30 ± 0.02 h; 1372 Haremari, P = 15.25 ± 0.03 h; 1416 Renauxa, P = 8.700 ± 0.004 h; 2181 Fogelin, P = 14.07 ± 0.01 h; 3458 Bodougnat, P = 3.8565 ± 0.0005 h; and 8062 Okhotsymskij, P = 5.282 ± 0.002 h.

Observations of six asteroids were made at the Shed of Science Observatory between 2009 September and 2010 March. A 0.35-m Schmidt-Cassegrain (SCT) was used with an SBIG ST10XE CCD camera working at a scale of 0.94 arcsec/pixel. Exposures were made through a Celestron UHC LPR filter. *MPO Canopus* was used to perform differential photometry on the reduced images.

616 Elly. This object was observed on two consecutive nights, 2010 February 24 and 25. Analysis indicates a period of *P* = 5.30 ± 0.02 h, *A* = 0.38 mag. This is in agreement with recent results by Warner (2010) and earlier results from Alvarez (2004) and Tedesco (2004). Due to the object’s short period and the long winter nights, we were able to complete the curve with partial double coverage on both evenings, giving it a reliability code of U = 3. (see Warner et al., 2009, for the definition of the U rating).

1372 Haremari. A period of *P* = 15.25 ± 0.03 h and *A* = 0.1 mag. were derived from seven nights’ observations. The curve is not complete and other solutions are possible. We give these results a reliability code of U = 2. The ambiguity could be resolved with more observations over a longer time period or, more quickly, by involving another observer at a well-removed longitude.

1416 Renauxa. The lightcurve of this object has been measured on other occasions by Tedesco et al. (2004) and Lagerkvist (1978), both of whom reported a monomodal curve with a period of ~4.3 h. Our observations indicate that the lightcurve has an asymmetric shape that slightly favors a bimodal solution with a period of *P* = 8.700 ± 0.004 h and *A* = 0.1 mag.

2181 Fogelin. A period of *P* = 14.07 ± 0.01 h and *A* = 0.57 mag were derived from four nights’ observations. This is the first known lightcurve of this object. We give it a reliability code of U = 3.

<u>3458 Bodougnat.</u> A period of $P = 3.8565 \pm 0.0005$ h and $A = 0.38$ mag were derived from three nights' observations with complete coverage of the lightcurve on two consecutive nights followed by a single night a month later. This is the first known lightcurve of this object; the observations support a reliability code of U = 3.

<u>8062 Okhotsymskij.</u> We derived a period of $P = 5.282 \pm 0.002$ h and $A = 0.49$ mag from three nights' observations. Observations on February 11 and 18 covered more than the entire period with the latter covering nearly two full rotations. This is the first known lightcurve of this object; we give it a U=3 reliability code.

## Acknowledgements

Partial funding at the Shed of Science is provided by a 2009 Gene Shoemaker NEO Grant from the Planetary Society.

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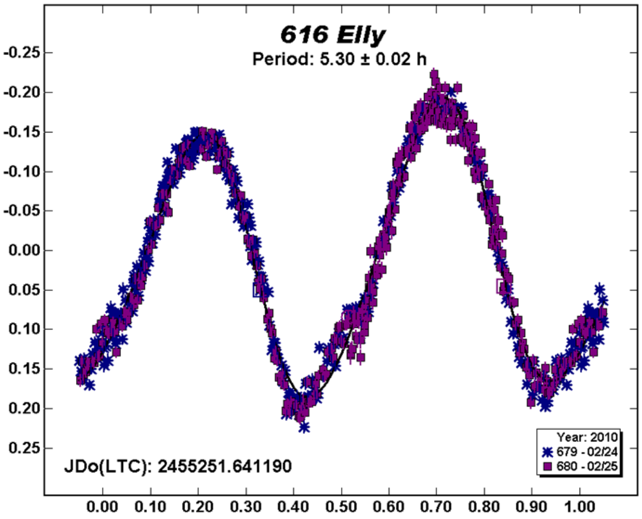

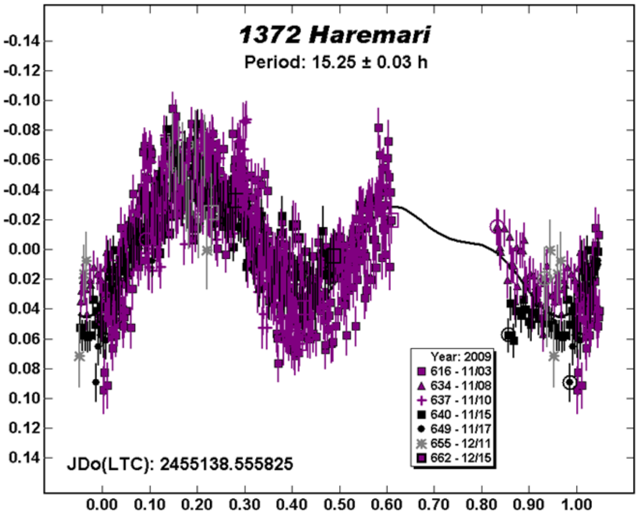

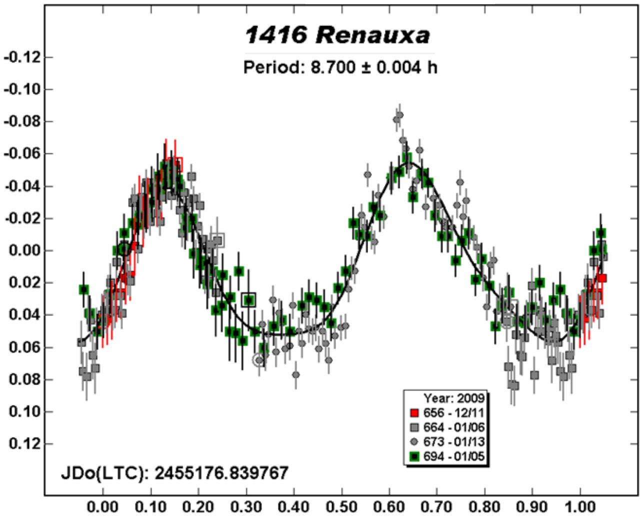

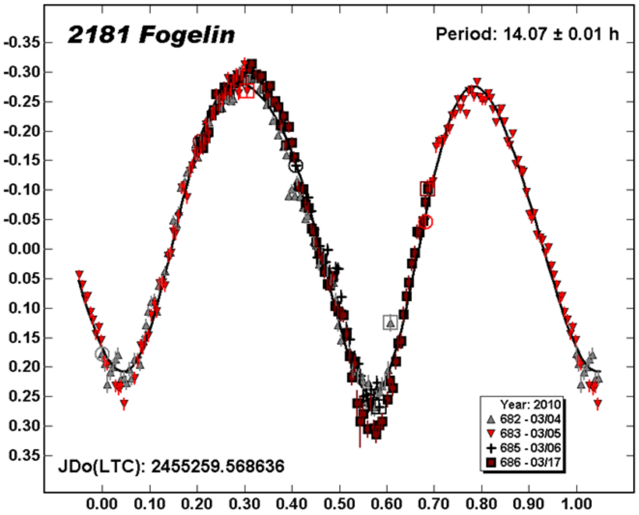

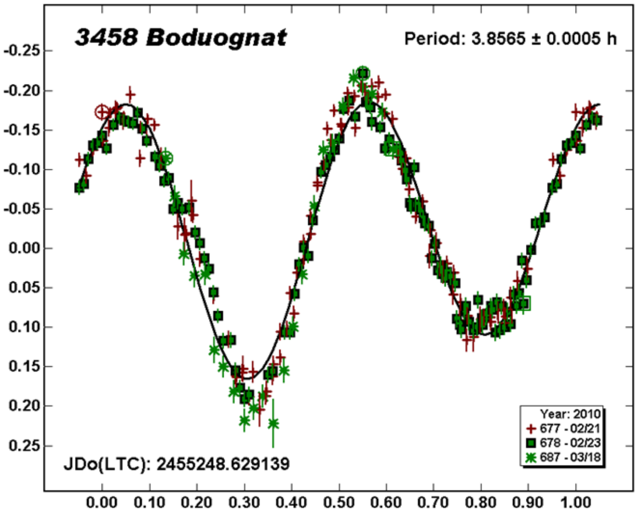

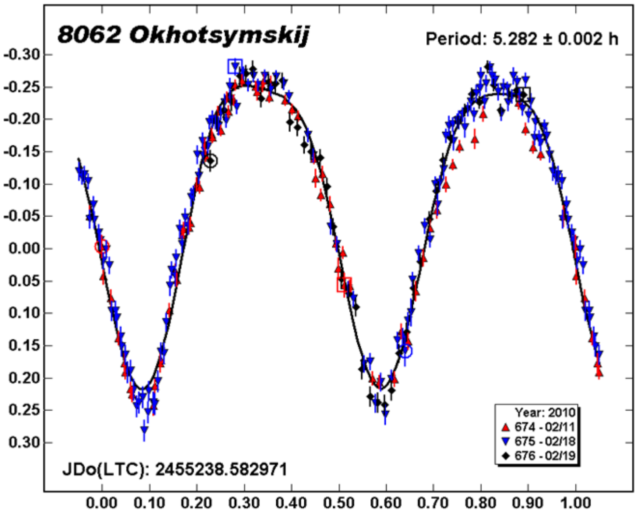

# UPON FUTHER REVIEW: I. AN EXAMINATION OF PREVIOUS LIGHTCURVE ANALYSIS FROM THE PALMER DIVIDE OBSERVATORY

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Updated results are given for ten asteroids previously reported from the Palmer Divide Observatory. The original images were re-measured to obtain new data sets using the latest version of MPO Canopus photometry software, analysis tools, and revised techniques for linking multiple observing runs covering several days to several weeks. Results that were previously not reported or had significantly different periods and/or amplitudes were found for 222 Lucia, 331 Etheridgea, 421 Zahringia, 506 Marion, 586 Thekla, 756 Lilliana, 862 Franzia, 957 Camelia, 1042 Amazone, and 1266 Tone. This is the first in a series of papers that will examine results obtained during the initial years of the asteroid lightcurve program at PDO.

The availability of improved analysis tools and techniques along with the experience gained over more than a decade of asteroid lightcurve photometry have lead to a program to re-examine the early work and results at the Palmer Divide Observatory (c. 1999-2006). In most cases, any changes in the period and/or amplitude as a result of the new analysis were statistically insignificant. However, there were some cases where the new results were significantly different. This paper is the first in a series that reports updated results from the new analysis, giving updates on 10 of the 17 significant revisions. Subsequent papers will complete the list of significant revisions and then those of lesser importance found in the initial stage of the re-evaluation program. Subsequent stages may result in additional updates.

*MPO Canopus*, developed by the author, is used exclusively at PDO. Since its first version, which did only the most essential functions of photometry, it has undergone a number of revisions. These now include an improved sky background algorithm, a star

| | | Original | | | | Revised | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| # | Name | Per | Amp | U | Ref | Per | PE | Amp | AE | U |
| 221 | Lucia | | | | Not previously published | 7.6 | 0.2 | 0.38 | 0.02 | 2 |
| 331 | Etheridgea | 6.82 | 0.05 | 2 | Warner; MPB 30, 61-64 | Long? | | | | 1 |
| 421 | Zahringia | 15.5 | 0.12 | 1 | Robinson; MPB 29, 30-31 | 6.42[2] | 0.01 | 0.10 | 0.01 | 2 |
| 506 | Marion | 10.58 | 0.35 | 2 | Robinson; MPB 29, 6-7 | 13.56 | 0.01 | 0.30 | 0.01 | 2 |
| 586 | Thekla | 10.630 | 0.24 | 2 | Warner; MPB 27, 20-21 | 13.68 | 0.01 | 0.29 | 0.01 | 2+ |
| 756 | Lilliana | | | | Not previously published | 9.37 | 0.05 | 0.30 | 0.02 | 2- |
| 862 | Franzia | 15.05[1] | 0.12 | 2 | Warner; MPB 32, 29-32 | 7.52 | 0.01 | 0.13 | 0.01 | 2+ |
| 862 | Franzia | | | | | 7.65[3] | 0.01 | 0.10 | 0.02 | 2 |
| 957 | Camelia | 5.391 | 0.32 | 2 | Warner; MPB 28, 4-5 | 150 | 30 | >0.30 | | 1+ |
| 1042 | Amazone | 16.26 | 0.10 | 2 | Warner; MPB 32, 90-92 | 540 | 30 | >0.25 | | 2 |
| 1266 | Tone | 11.82 | 0.12 | 2 | Warner; MPB 30, 61-64 | 7.4 | 0.1 | 0.06 | 0.01 | 2 |

Table I. Summary of original and revised results. The period is in hour and the amplitude is in magnitudes. The U code rating is based on the criteria outlined in the Lightcurve Database (Warner et al., 2009c). Unless otherwise stated, the references are from the *Minor Planet Bulletin* for the original results, with only the volume and page numbers given.

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[1] Ambiguous; 7.6 h also given.

[2] Ambiguous; 12.86 h also possible.

[3] Ambiguous; 15.27 h also possible.

subtraction algorithm to remove faint field stars near or merged with the asteroid, Fourier analysis based on the FALC algorithm by Harris (Harris et al., 1989), and use of the 2MASS catalog (Skrutskie et al., 2006) along with formulae to convert the J-K magnitudes to the BVRI system (see Warner 2007; Stephens 2008). These additional features made it worthwhile to review past results, not just by analyzing the original data but generating new data by re-measuring the original images.

Regenerating the data often resulted in data sets that were significantly less noisy, had fewer gaps (i.e., faint stars were removed instead of ignoring images where the asteroid and stars comingled), and could be linked over multiple nights with little or no guesswork due to the 2MASS-BVRI conversions. This last point was probably the most important in assessing the revised data. Without some sort of internal calibration, matching nightly runs could be highly subjective and result in totally incorrect results. For example, without the calibration it was not possible to determine that an asteroid was actually slowly increasing or decreasing in brightness (indicating a slow rotator). Instead, the tendency was to force the individual sessions to overlay one another and try to find a period, often based on what was only noise in the data. In recent years, the discovery of a strong excess of slow rotators among small asteroids (see Pravec, 2008; Warner, 2009b) and the need to understand "tumbling" asteroids (see Pravec, 2005) have made it even more important to provide linked data sets when they span many days or even weeks.

Re-examination of earlier results can prove a little embarrassing but it is better to be sure (as much as possible) of the data and subsequent results. Significant errors (and biases) can affect trend analysis in many ways. Re-examination can also lead to important new discoveries, e.g., going from a long period asteroid to being a probable binary (Warner et al., 2009a). If nothing else, going through the process of reviewing older data and results can further develop one's techniques and skill in asteroid photometry. That is always a worthwhile effort.

## Presentation of the New Analysis

Each paper in this series will give a brief analysis of the new data set and show a lightcurve based on that new data set, even if there is no significant difference in the period. The "improvement" may be a revised amplitude or simply "better data" to be used for modeling in the future (e.g., the U code may have a different rating; see Warner et al., 2009c, for information about the U code rating system). The exact observing details will not be given. Instead, a table will list the original and new results along with a reference to the original paper. The original reference gives data on the equipment used and references to results from other authors and so those will not be repeated here.

The plots show the *R-band* reduced magnitude of the asteroid This means that the data for each night were corrected to "unity distance" using –5*log(rR) where r was the Earth-asteroid distance and R was the Sun-asteroid distance, both in AU. The data were also corrected to the phase angle of the earliest session using $G = 0.15$ (unless otherwise stated).

222 Lucia. Despite the data being obtained 1999 April, the results were never published. The period given in the table is based on a half-period solution (monomodal curve). A better period solution was determined by Stephens (2009).

331 Etheridgea. The raw plot shows a small rise over several days, possibly indicating a long period. However, given the 13-day gap between the two sessions, it's entirely possible that they represent parts of a much shorter period lightcurve with an undetermined number of cycles in-between. If the two sessions are forced to overlap, a number of solutions with $P < 24$ can be found.

421 Zahringia. The lightcurve shows the monomodal solution of 6.42 ± 0.01 h. The double period of 12.86 ± 0.01 h, with a bimodal curve, cannot be formally excluded.

506 Marion. This corrects the period derived from the original data set. The new period agrees with subsequent results from this and other authors.

586 Thekla. This corrects the period derived from the original data set. It agrees with subsequent results.

756 Lilliana. The results of the original data set were not previously published. The period of 9.37 ± 0.05 h reported here is based on finding the half-period solution. Given the sparse data set, the period is in reasonable agreement with published results.

862 Franzia. Results from data sets obtained in 2000 and 2004 are reported here. Those from 2000 give a period of 7.52 ± 0.01 h while those from 2004 yield a solution of 7.65 ± 0.01 h or, less likely, 15.27 h.

957 Camelia. The revised data set indicates this to be a slow rotator, with a period on the order of 150 h. The previous result of $P \sim 5.4$ h was derived without the guidance of proper data set linking: the sessions were forced to overlay one another by using arbitrary zero point offsets.

1042 Amazone. This is another case where the arbitrary adjustment of nightly zero points likely lead to a false solution. The derived period of 540 ± 30 h is based on finding a half-period solution. The amplitude of > 0.25 mag makes it probable that the complete curve would be bimodal.

1266 Tone. The plot shows the monomodal solution of $P = 7.4$ h. The double period of 14.8 h cannot be formally excluded.

## Acknowledgements

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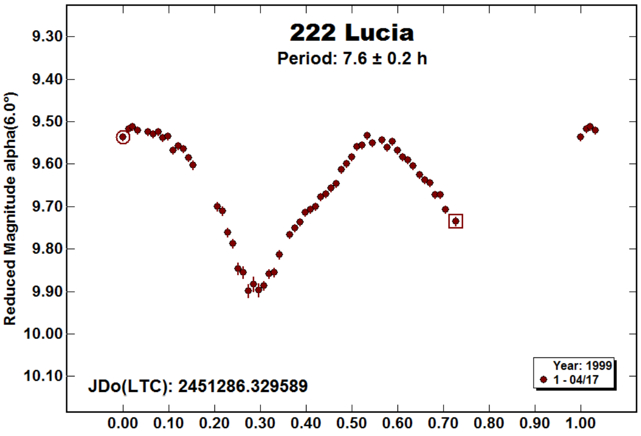

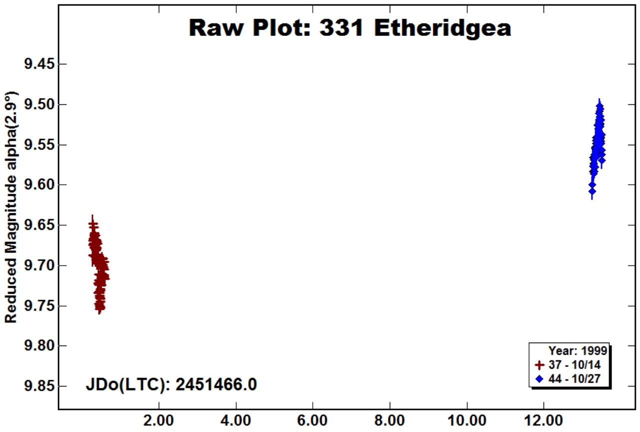

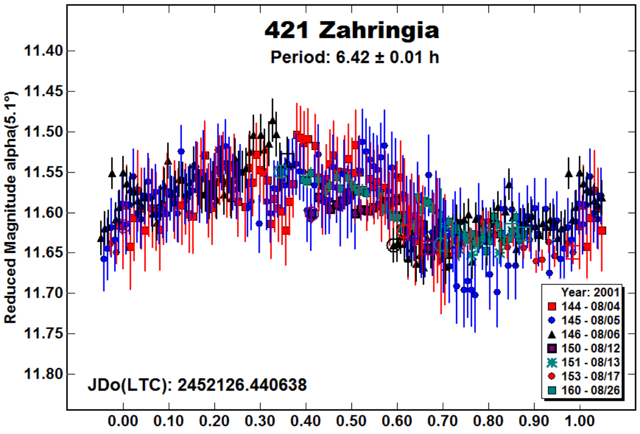

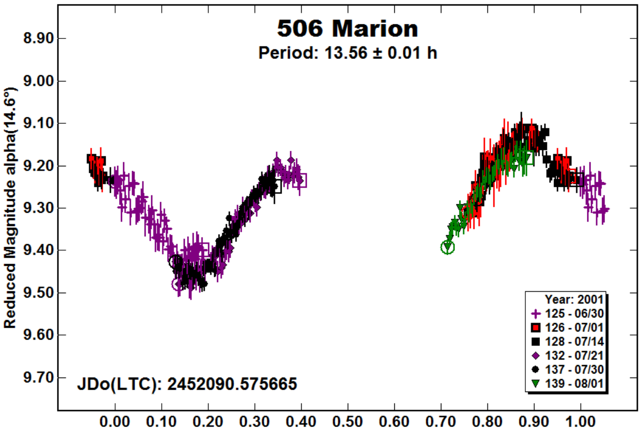

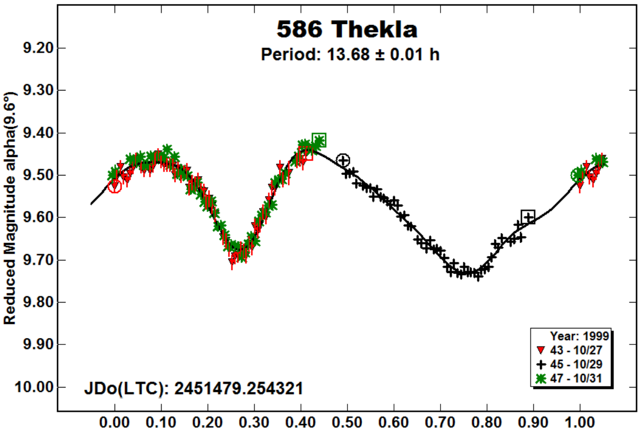

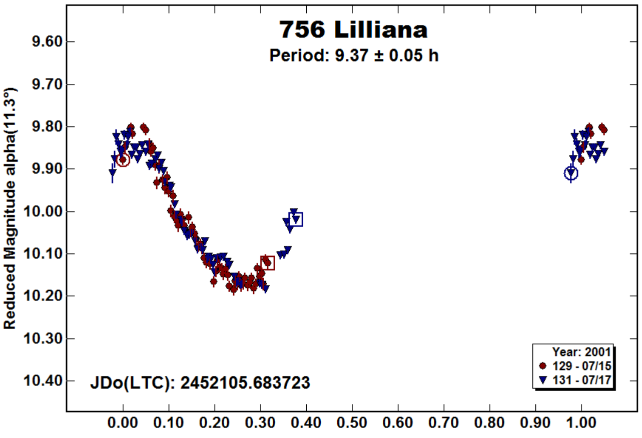

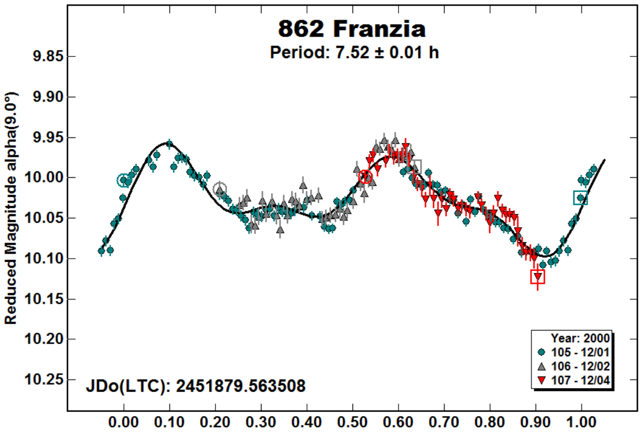

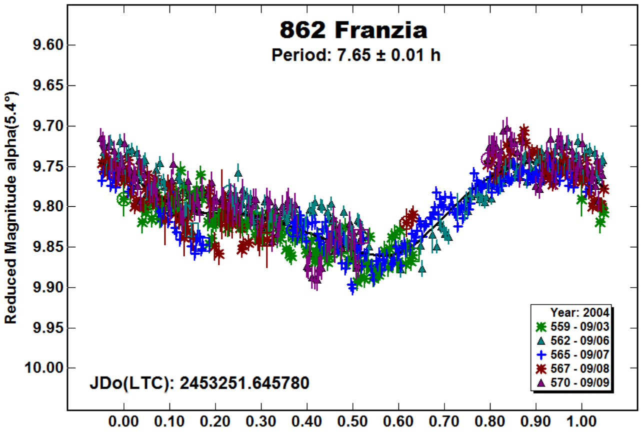

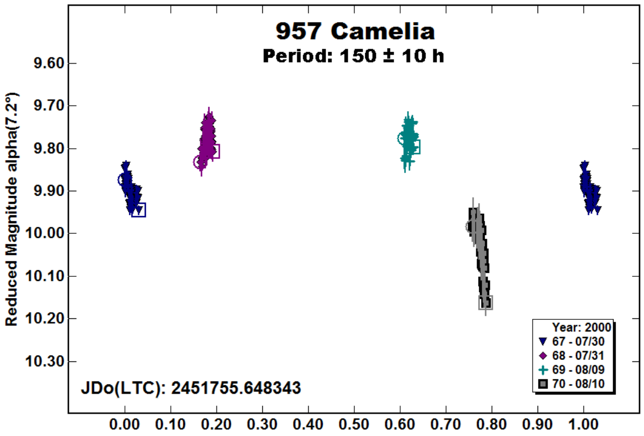

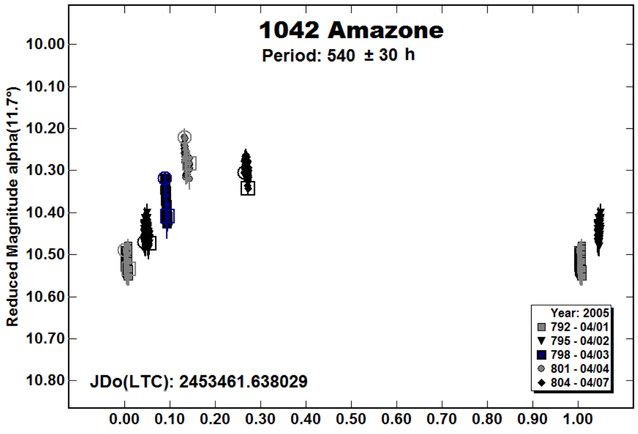

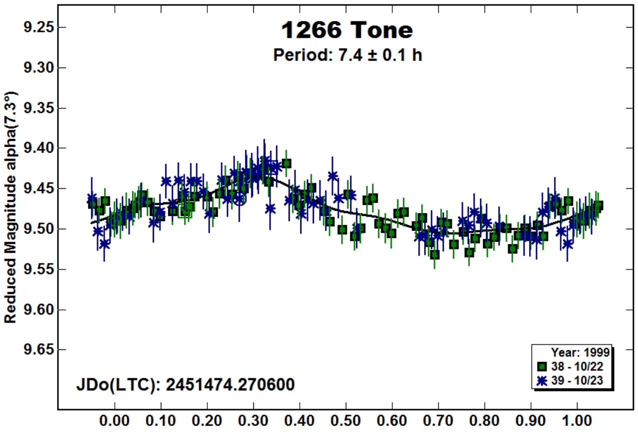

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## LIGHTCURVE PHOTOMETRY OPPORTUNITIES: 2010 JULY - SEPTEMBER

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This time we feature several NEAs for radar support that may present some challenges given their fast sky motion, faintness, and/or proximity to the Sun. For more background on the program details for each of the opportunity lists, refer to previous issues, e.g., *Minor Planet Bulletin* **36**, 188.

As always, we urge observations of asteroids even if they have well-established lightcurve parameters, especially if they do not yet have good spin axis or shape models. Every lightcurve of sufficient quality provides valuable information in support of such efforts, which are needed to resolve a number of questions about the evolution of individual asteroids and the general population. Furthermore, data over many apparitions can help determine if an asteroid’s rotation rate is being affected by the YORP effect, a thermal effect that can cause a smaller, irregularly-shaped asteroid to speed up or slow down. This is done by seeing if a constant sidereal period fits all the data equally well or if a small linear change in the period produces better results. See Lowry et al. (2007) *Science* **316**, 272-274 and Kaasalainen et al. (2007) *Nature* **446**, 420-422.

Lightcurves, new or repeats, of NEAs are also important for solving spin axis models, specifically the orientation of the asteroid's axis of rotation. Pole directions are known for only about 30 NEAs out of a population of 6800. This is hardly sufficient to make even the most general of statements about pole alignments, including whether or not YORP is forcing pole orientations into a limited number of preferred directions (see La Spina et al. (2004), *Nature* **428**, 400-401).

## The Opportunities Lists

We present four lists of "targets of opportunity" for the period 2010 July-September. In the first three sets of tables, Dec is the declination, U is the quality code of the lightcurve, and α is the solar phase angle. See the asteroid lightcurve data base (LCDB) documentation for an explanation of the U code:

*www.minorplanetobserver.com/astlc/LightcurveParameters.htm*

Note that the lightcurve amplitude in the tables could be more, or less, than what's given. Use the listing only as a guide.

Objects with no U rating or *U* = 1 should be given higher priority when possible. *We urge that you do not overlook asteroids with U = 2 on the assumption that the period is sufficiently established.* Regardless, do not let the existing period influence your analysis since even high quality ratings have been proven wrong at times.

The first list is an *abbreviated list* of those asteroids reaching V < 14.5 at brightest during the period and have either no or poorly constrained lightcurve parameters. The goal for these asteroids is to find a well-determined rotation rate. More completed lists, including objects V < 16.0 can be found on the CALL web site.

*http://www.minorplanetobserver.com/astlc/targets_3q_2010.htm*

The Low Phase Angle list includes asteroids that reach very low phase angles. Getting accurate, calibrated measurements (usually V band) at or very near the day of opposition can provide important information for those studying the "opposition effect."

The third list is of those asteroids needing only a small number of lightcurves to allow shape and spin axis modeling. Those doing work for modeling should contact Josef Durech at the email address above and visit the Database of Asteroid Models from Inversion Techniques (DAMIT) web site for existing data and models: *http://astro.troja.mff.cuni.cz/projects/asteroids3D.*

The fourth list gives a brief ephemeris for planned radar targets. Supporting optical observations made to determine the lightcurve period, amplitude, and shape are needed to supplement the radar data. High-precision work, 0.01-0.03 mag, is preferred. Those obtaining lightcurves in support of radar observations should contact Dr. Benner directly at the email given above.

Future radar targets:
*http://echo.jpl.nasa.gov/~lance/future.radar.nea.periods.html*
Past radar targets:
*http://echo.jpl.nasa.gov/~lance/radar.nea.periods.html*
Arecibo targets:
*http://www.naic.edu/~pradar/sched.shtml*
Goldstone targets:
*http://echo.jpl.nasa.gov/asteroids/goldstone_asteroid_schedule.html*

Once you have analyzed your data, it's important that you publish your results. Papers appearing in the *Minor Planet Bulletin* are indexed in the Astrophysical Data System (ADS) and so can be referenced by others in subsequent papers. It's also important to make the data available at least on a personal website or upon request.

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## Lightcurve Opportunities

| | | Brightest | | | | LCDB Data | |
|---|---|---|---|---|---|---|---|
| # | Name | Date | Mag | Dec | U | Period | Amp |
| 1211 | Bressole | 7 02.6 | 14.2 | -13 | | | |
| 1329 | Eliane | 7 04.6 | 13.4 | - 9 | 2- | 106. | >0.30 |
| 1850 | Kohoutek | 7 07.8 | 14.5 | -27 | | | |
| 19261 | 1995 MB | 7 09.5 | 13.9 | -13 | | | |
| 10487 | Danpeterson | 7 11.6 | 14.1 | -33 | | | |
| 11277 | Ballard | 7 11.7 | 14.9 | +10 | | | |
| 664 | Judith | 7 12.5 | 13.3 | - 9 | 2 | 10.76 | 0.4 |
| 2575 | Bulgaria | 7 13.0 | 14.4 | -27 | | | |
| 1867 | Deiphobus | 7 13.3 | 14.8 | -17 | 2 | > 24. | >0.1 |
| 1780 | Kippes | 7 13.7 | 14.3 | -22 | 2 | 18.0 | 0.23 |
| 2407 | Haug | 7 13.6 | 13.8 | -25 | | | |
| 15491 | 1999 CW85 | 7 15.7 | 14.4 | -29 | | | |
| 3145 | Walter Adams | 7 17.9 | 15.0 | -19 | 2 | 2.7 | 0.2 |
| 953 | Painleva | 7 18.8 | 13.1 | -36 | 1 | 10. | 0.03-0.10 |
| 2880 | Nihondaira | 7 21.5 | 14.0 | -32 | 2 | 17.97 | 0.75 |
| 5430 | Luu | 7 22.6 | 14.2 | -17 | 2 | 13.55 | 0.06 |
| 4297 | Eichhorn | 7 23.0 | 13.8 | -20 | | | |
| 1594 | Danjon | 7 30.7 | 13.7 | -34 | 1 | > 12. | >0.03 |
| 4331 | Hubbard | 8 01.6 | 14.4 | -28 | | | |
| 1266 | Tone | 8 06.4 | 13.9 | -20 | 2 | 7.40 | 0.06 |
| 370 | Modestia | 8 06.5 | 12.9 | -11 | 2- | > 24. | 0.40 |
| 21632 | Suwanasri | 8 07.5 | 14.7 | -12 | | | |
| 4691 | Toyen | 8 09.0 | 14.7 | -29 | | | |
| 7178 | Ikuookamoto | 8 10.6 | 14.7 | -17 | | | |
| 14425 | 1991 TJ2 | 8 11.6 | 14.4 | -28 | | | |
| 1353 | Maartje | 8 12.4 | 14.2 | - 2 | 2 | 22.98 | 0.40 |
| 3173 | McNaught | 8 15.3 | 14.5 | -28 | | | |
| 1746 | Brouwer | 8 16.1 | 14.4 | -14 | 2 | 19.8 | 0.35 |
| 2607 | Yakutia | 8 17.9 | 14.5 | -16 | | | |
| 3053 | Dresden | 8 18.2 | 14.3 | -20 | | | |
| 3662 | Dezhnev | 8 19.1 | 14.5 | -24 | | | |
| 3833 | Calingasta | 8 23.4 | 14.5 | + 1 | | | |
| 2025 | Nortia | 8 24.7 | 14.5 | -11 | | | |
| 504 | Cora | 8 24.1 | 11.9 | -27 | 2 | 7.59 | 0.27 |
| 1701 | Okavango | 8 26.4 | 14.3 | -34 | 2 | 13.20 | 0.45 |
| 3104 | Durer | 8 27.8 | 14.4 | - 5 | | | |
| 1699 | Honkasalo | 9 01.4 | 13.7 | - 5 | 2 | 12.30 | 0.15 |
| 448 | Natalie | 9 01.1 | 13.8 | -25 | | | |
| 154029 | 2002 CY46 | 9 04.5 | 14.5 | +29 | | | |
| 103 | Hera | 9 04.1 | 10.7 | -11 | 2 | 23.74 | 0.42 |
| 938 | Chlosinde | 9 05.1 | 13.9 | -10 | | | |
| 3184 | Raab | 9 05.7 | 14.0 | -20 | | | |
| 672 | Astarte | 9 05.9 | 13.5 | - 7 | 2 | 19.8 | 0.10 |
| 1730 | Marceline | 9 06.6 | 14.0 | - 4 | | | |
| 1811 | Bruwer | 9 09.2 | 14.4 | - 5 | | | |
| 2715 | Mielikki | 9 14.6 | 14.5 | + 2 | | | |
| 10452 | Zuev | 9 16.1 | 14.4 | + 2 | | | |
| 3921 | Klement'ev | 9 16.9 | 14.2 | -10 | | | |
| 10357 | 1993 SL3 | 9 17.3 | 14.5 | -21 | | | |
| 3408 | Shalamov | 9 18.5 | 14.2 | - 6 | | | |
| 1519 | Kajaani | 9 18.5 | 14.2 | - 9 | | | |
| 3295 | Murakami | 9 19.1 | 14.5 | - 4 | | | |
| 3883 | Verbano | 9 20.1 | 14.4 | - 4 | | | |
| 19288 | 1996 FJ5 | 9 21.0 | 14.9 | - 8 | 2 | 2.65 | 0.13 |
| 1493 | Sigrid | 9 21.7 | 13.5 | + 2 | 2 | 43.29 | >0.6 |
| 1619 | Ueta | 9 27.7 | 13.7 | - 9 | 2 | 2.94 | 0.44 |
| 2550 | Houssay | 9 28.7 | 14.8 | - 5 | | | |
| 2650 | Elinor | 9 29.0 | 13.9 | +17 | 2 | 9.08 | 0.12 |

## Low Phase Angle Opportunities

| # | Name | Date | α | V | Dec | Period | Amp | U |
|---|---|---|---|---|---|---|---|---|
| 2264 | Sabrina | 7 03.5 | 0.17 | 13.8 | -23 | 43.41 | 0.30 | 2 |
| 678 | Fredegundis | 7 04.2 | 0.13 | 12.5 | -23 | 11.61624 | 0.27 | 3 |
| 184 | Dejopeja | 7 07.7 | 0.39 | 12.7 | -24 | 6.455 | 0.25-0.3 | 3 |
| 1107 | Lictoria | 7 08.1 | 0.26 | 14.0 | -22 | 8.5616 | 0.16-0.30 | 3 |
| 758 | Mancunia | 7 08.2 | 0.07 | 12.9 | -22 | 12.724 | 0.15-0.26 | 3 |
| 177 | Irma | 7 09.0 | 0.73 | 12.9 | -24 | 14.208 | 0.37 | 2 |
| 512 | Taurinensis | 7 09.8 | 0.19 | 11.8 | -22 | 5.585 | 0.14-0.35 | 3 |

## Low Phase Angle Opportunities (continued)

| # | Name | Date | α | V | Dec | Period | Amp | U |
|---|---|---|---|---|---|---|---|---|
| 371 | Bohemia | 7 11.4 | 0.45 | 11.8 | -21 | 10.739 | 0.13-0.18 | 3 |
| 122 | Gerda | 7 12.5 | 0.67 | 12.4 | -20 | 10.685 | 0.11-0.26 | 3 |
| 24 | Themis | 7 20.1 | 0.31 | 11.8 | -22 | 8.374 | 0.09-0.14 | 3 |
| 300 | Geraldina | 7 20.1 | 0.34 | 13.8 | -22 | 6.8423 | 0.15-0.32 | 3 |
| 696 | Leonora | 7 20.5 | 0.26 | 13.3 | -21 | 17.988 | 0.10 | 2 |
| 4297 | Eichhorn | 7 23.0 | 0.24 | 13.8 | -20 | | | |
| 551 | Ortrud | 7 29.1 | 0.17 | 13.8 | -19 | 13.05 | 0.16 | 3 |
| 2217 | Eltigen | 8 04.0 | 0.09 | 14.0 | -18 | | | |
| 206 | Hersilia | 8 09.1 | 0.34 | 12.3 | -15 | 11.11 | 0.08-0.14 | 3 |
| 240 | Vanadis | 8 11.0 | 0.52 | 12.2 | -17 | 10.64 | 0.34 | 3 |
| 215 | Oenone | 8 18.2 | 0.89 | 13.0 | -15 | 20. | 0.1 | 2 |
| 954 | Li | 8 19.1 | 0.22 | 13.1 | -12 | 7.207 | 0.11-0.25 | 3 |
| 1182 | Ilona | 8 23.5 | 0.95 | 13.4 | -13 | 29.8 | 1.2 | 2 |
| 469 | Argentina | 8 24.4 | 0.29 | 13.5 | -12 | 17.573 | 0.12 | 3 |
| 1187 | Afra | 8 27.0 | 0.89 | 13.8 | -08 | 14.0701 | 0.38 | 3 |
| 203 | Pompeja | 8 29.2 | 0.42 | 12.1 | -10 | 46.6 | 0.10 | 2 |
| 77 | Frigga | 8 31.0 | 0.63 | 11.7 | -10 | 9.012 | 0.07-0.20 | 3 |
| 82 | Alkmene | 9 05.9 | 0.85 | 12.9 | -09 | 12.999 | 0.18-0.54 | 3 |
| 672 | Astarte | 9 05.9 | 0.15 | 13.5 | -07 | 19.8 | 0.10 | 2 |
| 808 | Merxia | 9 09.3 | 0.67 | 13.4 | -04 | 30.631 | 0.70 | 3 |
| 1247 | Memoria | 9 16.8 | 0.22 | 14.0 | -03 | | | |
| 158 | Koronis | 9 19.0 | 0.55 | 12.9 | +00 | 14.218 | 0.28-0.43 | 3 |
| 108 | Hecuba | 9 24.5 | 0.34 | 12.8 | +02 | 17.859 | 0.05-0.2 | 3 |
| 604 | Tekmessa | 9 26.3 | 0.45 | 12.4 | +00 | 5.5596 | 0.52 | 3 |
| 417 | Suevia | 9 28.7 | 0.76 | 13.7 | +04 | 7.034 | 0.22 | 3 |
| 585 | Bilkis | 9 29.2 | 0.45 | 13.7 | +01 | 6.442 | 0.38 | 2 |
| 5567 | Durisen | 9 29.2 | 0.68 | 13.6 | +01 | | | |

## Shape/Spin Modeling Opportunities

| | | Brightest | | | Per | | |
|---|---|---|---|---|---|---|---|
| # | Name | Date | Mag | Dec | (h) | Amp | U |
| 288 | Glauke | 7 12.9 | 13.0 | -21 | 1200. | 0.58-0.9 | 3 |
| 451 | Patientia | 7 14.8 | 11.1 | -30 | 9.727 | 0.05-0.10 | 3 |
| 24 | Themis | 7 20.1 | 11.8 | -22 | 8.374 | 0.09-0.14 | 3 |
| 190 | Ismene | 7 23.3 | 13.7 | -14 | 6.52 | 0.10-0.15 | 3 |
| 372 | Palma | 8 03.8 | 12.3 | -28 | 8.567 | 0.10-0.17 | 3 |
| 146 | Lucina | 8 07.4 | 12.0 | -31 | 18.557 | 0.08-0.17 | 3 |
| 291 | Alice | 8 11.8 | 14.2 | -14 | 4.313 | 0.14-0.28 | 3 |
| 31 | Euphrosyne | 8 20.0 | 12.2 | -46 | 5.530 | 0.08-0.13 | 3 |
| 14 | Irene | 8 22.1 | 10.4 | -23 | 15.028 | 0.08-0.16 | 3 |
| 83 | Beatrix | 8 22.9 | 11.9 | -18 | 10.16 | 0.06-0.27 | 3 |
| 77 | Frigga | 8 31.1 | 11.6 | -10 | 9.012 | 0.07-0.20 | 3 |
| 369 | Aeria | 8 31.9 | 11.7 | -26 | 4.787 | 0.08 | 2 |
| 441 | Bathilde | 9 06.5 | 12.5 | +05 | 10.446 | 0.18 | 3 |
| 100 | Hekate | 9 24.7 | 11.3 | -07 | 27.066 | 0.11-0.23 | 3 |
| 233 | Asterope | 9 28.1 | 11.1 | +09 | 19.70 | 0.25-0.55 | 3 |

## Radar-Optical Opportunities

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

Minor Planet Center: *http://cfa-www.harvard.edu/iau/mpc.html*
JPL Horizons: *http://ssd.jpl.nasa.gov/?horizons*

Some objects are best seen outside July-September. We present them now to give you ample time for planning.

### 2002 BF25 (2010 July, H = 22.3)

The estimated size for this NEA is 100 meters. There are no lightcurve parameters in the LCDB. The apparition favors Southern Hemisphere observers with larger instruments.

| DATE | RA(2000) | DC(2000) | E.D. | S.D. | Mag | α |
|---|---|---|---|---|---|---|
| 07/10 | 23 46.43 | -54 43.0 | 0.046 | 1.041 | 17.78 | 56.9 |
| 07/11 | 00 09.81 | -54 01.4 | 0.043 | 1.037 | 17.68 | 59.9 |
| 07/12 | 00 35.93 | -52 51.8 | 0.039 | 1.034 | 17.61 | 63.4 |
| 07/13 | 01 04.55 | -51 04.2 | 0.036 | 1.030 | 17.55 | 67.6 |
| 07/14 | 01 35.11 | -48 27.1 | 0.034 | 1.026 | 17.52 | 72.6 |
| 07/15 | 02 06.70 | -44 49.4 | 0.031 | 1.022 | 17.55 | 78.4 |
| 07/16 | 02 38.20 | -40 03.1 | 0.029 | 1.019 | 17.64 | 85.1 |
| 07/17 | 03 08.53 | -34 08.3 | 0.028 | 1.015 | 17.83 | 92.6 |

### (85989) 1996 JD6 (2010 July, H = 17.1)

This NEA has a well-established period of 7.66 h. It also tends to have a large amplitude, ~1.0 mag, which should make it an interesting study. Lightcurve observations here can help determine the rotational phase at the time of radar observations and be used to see if the YORP effect has changed the rotation period.

| DATE | RA(2000) | DC(2000) | E.D. | S.D. | Mag | α |
|---|---|---|---|---|---|---|
| 07/05 | 19 45.74 | +14 55.8 | 0.265 | 1.232 | 16.02 | 31.8 |
| 07/10 | 19 17.00 | +16 00.4 | 0.221 | 1.198 | 15.57 | 31.7 |
| 07/15 | 18 35.12 | +16 35.3 | 0.184 | 1.162 | 15.19 | 35.1 |
| 07/20 | 17 36.17 | +15 59.6 | 0.156 | 1.122 | 15.01 | 44.2 |
| 07/25 | 16 21.26 | +13 20.6 | 0.140 | 1.079 | 15.14 | 59.8 |
| 07/30 | 15 02.21 | +08 41.7 | 0.141 | 1.033 | 15.67 | 78.8 |
| 08/04 | 13 53.91 | +03 39.4 | 0.157 | 0.984 | 16.52 | 96.9 |

### 2005 ED318 (2010 July, H = 20.8)

Radar observations are available but unpublished for this ~200-meter NEA. It does have established lightcurve parameters, *P* = 17.157 h and *A* = 0.22-0.48 mag, but additional lightcurves can serve to constrain pole and shape models. This object is fainter than we usually include but with access to 1 to 2-meter telescopes not out of the question these days, it's hoped that some Southern Hemisphere observers can make a project of it.

| DATE | RA(2000) | DC(2000) | E.D. | S.D. | Mag | α |
|---|---|---|---|---|---|---|
| 07/01 | 14 57.56 | -25 57.7 | 0.071 | 1.063 | 16.96 | 47.1 |
| 07/03 | 15 29.17 | -28 58.5 | 0.073 | 1.070 | 16.90 | 41.8 |
| 07/05 | 16 00.24 | -31 19.3 | 0.077 | 1.077 | 16.89 | 37.0 |
| 07/07 | 16 29.67 | -33 00.2 | 0.082 | 1.084 | 16.91 | 32.9 |
| 07/09 | 16 56.71 | -34 06.0 | 0.087 | 1.092 | 16.98 | 29.4 |
| 07/11 | 17 20.96 | -34 43.5 | 0.094 | 1.100 | 17.07 | 26.5 |

### 3122 Florence (2010 July-September, H = 14.2)

While not a radar target until later this decade, lightcurve data obtained during this apparition can help with future modeling (see the opening section above). The period is well established, 2.358 h, which makes a prime candidate for being a binary. Careful and high-precision observations should be made to check for this possibility.

| DATE | RA(2000) | DC(2000) | E.D. | S.D. | Mag | α |
|---|---|---|---|---|---|---|
| 07/01 | 0 44.04 | -29 58.7 | 0.538 | 1.232 | 15.29 | 54.3 |
| 07/11 | 1 17.39 | -22 13.8 | 0.463 | 1.180 | 14.99 | 58.4 |
| 07/21 | 1 51.41 | -11 48.7 | 0.401 | 1.132 | 14.73 | 63.2 |
| 07/31 | 2 27.49 | +01 36.3 | 0.357 | 1.090 | 14.56 | 68.5 |
| 08/10 | 3 07.47 | +17 08.5 | 0.339 | 1.057 | 14.54 | 73.4 |
| 08/20 | 3 53.38 | +32 20.8 | 0.348 | 1.034 | 14.66 | 76.6 |
| 08/30 | 4 46.93 | +44 39.7 | 0.381 | 1.022 | 14.85 | 77.4 |
| 09/09 | 5 47.65 | +53 04.0 | 0.427 | 1.022 | 15.05 | 76.0 |
| 09/19 | 6 51.21 | +57 55.2 | 0.478 | 1.034 | 15.23 | 73.1 |
| 09/29 | 7 51.11 | +60 10.0 | 0.528 | 1.056 | 15.37 | 69.5 |

**(4034) 1986 PA (2010 July-September, H = 18.4)**
This NEA will be a stretch even for those with access to larger instruments. However, lightcurve data of sufficient quality on the 620-meter asteroid could refine bounds for the pole-dimensions and optical albedo that were found with previous radar observations.

| DATE | RA(2000) | DC(2000) | E.D. | S.D. | Mag | α |
|---|---|---|---|---|---|---|
| 07/01 | 21 12.77 | +05 20.9 | 0.575 | 1.469 | 19.35 | 30.5 |
| 07/11 | 21 00.83 | +05 37.1 | 0.492 | 1.440 | 18.81 | 25.2 |
| 07/21 | 20 40.58 | +04 48.1 | 0.422 | 1.405 | 18.24 | 19.3 |
| 07/31 | 20 11.85 | +02 28.5 | 0.369 | 1.364 | 17.78 | 16.2 |
| 08/10 | 19 36.94 | -01 32.6 | 0.335 | 1.317 | 17.67 | 21.7 |
| 08/20 | 19 01.18 | -06 49.3 | 0.320 | 1.264 | 17.83 | 33.4 |
| 08/30 | 18 30.01 | -12 29.6 | 0.322 | 1.205 | 18.10 | 46.2 |
| 09/09 | 18 05.91 | -17 55.1 | 0.331 | 1.140 | 18.39 | 58.5 |
| 09/19 | 17 48.21 | -22 54.5 | 0.341 | 1.069 | 18.67 | 69.9 |
| 09/29 | 17 33.70 | -27 34.3 | 0.348 | 0.993 | 18.93 | 81.3 |

**6239 Minos (2010 August-September, H = 18.2)**
Pravec determined a period of 3.5558 h based observations in 2004 for this NEA. Data this apparition can see if the amplitude (0.08 mag in 2004) is different. If so, that will help with spin axis modeling. Radar observations show a near-spheroid with D ~ 500 m.

| DATE | RA(2000) | DC(2000) | E.D. | S.D. | Mag | α |
|---|---|---|---|---|---|---|
| 08/10 | 3 23.90 | +02 32.7 | 0.099 | 1.015 | 16.24 | 86.5 |
| 08/15 | 2 16.85 | +00 23.8 | 0.101 | 1.051 | 15.65 | 65.4 |
| 08/20 | 1 16.42 | -01 37.1 | 0.112 | 1.086 | 15.38 | 46.3 |
| 08/25 | 0 27.30 | -03 13.9 | 0.129 | 1.120 | 15.30 | 30.2 |
| 08/30 | 23 49.63 | -04 25.5 | 0.152 | 1.154 | 15.32 | 17.2 |
| 09/04 | 23 21.47 | -05 16.6 | 0.179 | 1.186 | 15.34 | 6.7 |
| 09/09 | 23 00.72 | -05 52.3 | 0.211 | 1.218 | 15.46 | 1.7 |
| 09/14 | 22 45.67 | -06 16.2 | 0.246 | 1.248 | 16.22 | 8.5 |

**(154029) 2002 CY46 (2010 August-September, H = 16.4)**
There are no known lightcurve parameters for this NEA of about 1.6 km size. Mid- to late September may be the best chance to work the asteroid, when its sky motion is considerably slower.

| DATE | RA(2000) | DC(2000) | E.D. | S.D. | Mag | α |
|---|---|---|---|---|---|---|
| 08/20 | 4 03.79 | -21 56.4 | 0.246 | 1.053 | 16.04 | 73.6 |
| 08/25 | 3 34.43 | -10 55.1 | 0.201 | 1.070 | 15.45 | 67.7 |
| 08/30 | 2 53.49 | +05 19.0 | 0.171 | 1.089 | 14.85 | 58.3 |
| 09/04 | 1 57.32 | +24 49.9 | 0.165 | 1.110 | 14.54 | 48.6 |
| 09/09 | 0 47.44 | +40 45.8 | 0.188 | 1.134 | 14.73 | 44.1 |
| 09/14 | 23 35.77 | +49 26.6 | 0.230 | 1.159 | 15.22 | 43.9 |
| 09/19 | 22 36.54 | +52 49.7 | 0.283 | 1.185 | 15.75 | 44.9 |
| 09/24 | 21 54.24 | +53 36.4 | 0.343 | 1.213 | 16.23 | 45.5 |

**(137032) 1998 UO1 (2010 October, H = 16.7)**
Periods ranging from ~3 to 4 h have been reported for this NEA. Radar observations show *D* ~ 1.2 km and a nearly spheroidal shape. There were hints of a companion in the radar but nothing conclusive. High-precision observations will be needed to have any chance of detecting a satellite, if it exists. Note that ephemeris has 1-day intervals.

| DATE | RA(2000) | DC(2000) | E.D. | S.D. | Mag | α |
|---|---|---|---|---|---|---|
| 10/01 | 16 25.13 | +11 06.4 | 0.082 | 0.964 | 15.69 | 115.0 |
| 10/02 | 17 12.73 | +14 35.2 | 0.084 | 0.978 | 15.07 | 103.4 |
| 10/03 | 17 58.13 | +17 16.0 | 0.089 | 0.993 | 14.71 | 92.6 |
| 10/04 | 18 38.41 | +19 03.8 | 0.097 | 1.007 | 14.55 | 83.2 |
| 10/05 | 19 12.43 | +20 08.1 | 0.107 | 1.022 | 14.52 | 75.4 |
| 10/06 | 19 40.42 | +20 42.2 | 0.119 | 1.036 | 14.58 | 69.2 |
| 10/07 | 20 03.26 | +20 57.3 | 0.132 | 1.050 | 14.68 | 64.1 |
| 10/08 | 20 21.93 | +21 01.1 | 0.146 | 1.064 | 14.80 | 60.0 |
| 10/09 | 20 37.33 | +20 58.4 | 0.160 | 1.078 | 14.94 | 56.7 |
| 10/10 | 20 50.17 | +20 52.2 | 0.176 | 1.092 | 15.09 | 54.0 |

**(153814) 2001 WN5 (2010 October, H = 18.3)**
There are no known lightcurve parameters for this NEA. Its estimate size is about 650 meters. The somewhat fast sky motion and estimated magnitude favors larger telescopes so that exposure times can be kept to a minimum. In 2028, the asteroid passes at 0.6 lunar distances, the closest known approach by an object of this size for the next two centuries.

| DATE | RA(2000) | DC(2000) | E.D. | S.D. | Mag | α |
|---|---|---|---|---|---|---|
| 10/01 | 17 36.01 | -08 24.8 | 0.127 | 0.980 | 17.21 | 96.0 |
| 10/06 | 18 41.50 | -05 32.6 | 0.112 | 1.003 | 16.54 | 85.2 |
| 10/11 | 19 58.70 | -01 34.3 | 0.107 | 1.029 | 16.00 | 70.9 |
| 10/16 | 21 14.43 | +02 29.6 | 0.115 | 1.056 | 15.78 | 56.5 |
| 10/21 | 22 16.64 | +05 36.7 | 0.134 | 1.085 | 15.85 | 45.4 |
| 10/26 | 23 03.11 | +07 39.4 | 0.161 | 1.116 | 16.11 | 38.1 |
| 10/31 | 23 37.20 | +08 57.2 | 0.194 | 1.148 | 16.45 | 33.9 |
| 11/05 | 0 02.79 | +09 48.9 | 0.231 | 1.181 | 16.83 | 31.6 |

**(162269) 1999 VO6 (2010 October, H = 17.0)**
This NEA has an estimated size of 1.2 km. There are no known lightcurve parameters. It's decidedly a Northern Hemisphere target as it rides near the north celestial pole during October.

| DATE | RA(2000) | DC(2000) | E.D. | S.D. | Mag | α |
|---|---|---|---|---|---|---|
| 10/01 | 3 32.88 | +64 26.1 | 0.254 | 1.115 | 16.34 | 57.5 |
| 10/03 | 3 53.35 | +67 04.1 | 0.221 | 1.090 | 16.08 | 60.7 |
| 10/05 | 4 27.82 | +70 14.4 | 0.189 | 1.065 | 15.82 | 65.0 |
| 10/07 | 5 34.33 | +73 40.3 | 0.158 | 1.040 | 15.57 | 71.1 |
| 10/09 | 7 47.01 | +75 13.4 | 0.130 | 1.014 | 15.39 | 79.9 |
| 10/11 | 10 26.57 | +69 09.9 | 0.106 | 0.987 | 15.42 | 93.2 |
| 10/13 | 11 58.40 | +53 15.5 | 0.091 | 0.960 | 16.03 | 112.3 |

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## IN THIS ISSUE

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

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| 48154 | 2001 GT3 | 112 | 32 |
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* * * * *

The deadline for the next issue (37-4) is July 15, 2010. The deadline for issue 38-1 is October 15, 2010.