THE MINOR PLANET BULLETIN

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

VOLUME 38, NUMBER 1, A.D. 2011 JANUARY-MARCH

878 MILDRED REVEALED

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

Linda M. French
Illinois Wesleyan University
Bloomington, IL 61702 USA

(Received: 13 October)

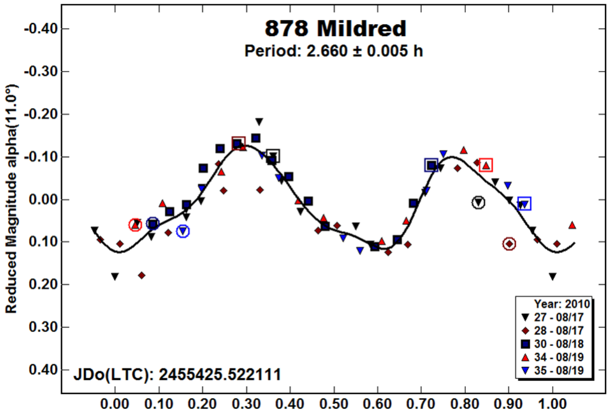
Observations of the main-belt asteroid 878 Mildred made at Cerro Tololo Interamerican Observatory in August 2010 found a synodic period of 2.660 ± 0.005 h and an amplitude of 0.23 ± 0.03 mag.

Asteroid 878 Mildred has a famous history as a small solar system body. It was originally discovered on September 6, 1916, by Seth Nicholson (1916) and Harlow Shapley using the 1.5 m Hale Telescope at Mount Wilson Observatory, the world's largest telescope at the time. Thinking the orbit was unusual; Nicholson and Shapley continued to observe the asteroid until October 18. It was then lost for 75 years.

The asteroid was named for Shapley's infant daughter "Mildred". Like her famous father, Mildred Shapley Matthews went on to work in the field of astronomy, becoming a research assistant and editor of many astronomy books.

Several attempts to recover 878 Mildred were unsuccessful. Then on April 10, 1991, the ESO 1-meter telescope at La Silla recorded several asteroids on a plate. Gareth Williams working at the Minor Planet Center realized that one of the asteroids fit the orbit predicted by the 1916 measurements of Mildred (Messenger 1991). Working backwards, Williams found another single observation of the asteroid from 1985. More single-night observations in 1984 and 1977 were then found making its orbit well established. At the time of Mildred's recovery, there was only one asteroid still "lost" – 719 Albert. Albert was subsequently found in 2000.

Although 878 Mildred is no longer lost, very little is known about its physical properties. It is in the Main Belt and is the namesake of the Mildred family (Mothé-Diniz 2005), a subgroup of the Nysa family. The Mildred subgroup is thought to have been recently formed and consists of over 1,200 members.



In August, French and Stephens were using the 0.9-m telescope at Cerro Tololo Inter-American Observatory in Chile to study Trojan asteroids. While observing a Trojan, we blinked several images and noticed a moving object tracking the target. A check of the field showed the second asteroid was 878 Mildred.

Realizing the opportunity, we reduced the images the following day and derived a preliminary lightcurve suggesting a short rotational period. Mildred was still in the field of the targeted Trojan the next night so more data was obtained. Since it appeared that a third night would add a sufficient level of confidence to the derived period, Mildred was made a primary target.

A search of the Asteroid Lightcurve Data file (Warner 2010) did not reveal any previously reported periods. The final data set has 64 data points over three consecutive nights. Analysis of the lightcurve determined a synodic period of 2.660 ± 0.005 h with an amplitude of 0.23 ± 0.03 mag.

Acknowledgements

This research was supported by Cottrell College Science Award grants from the Research Corporation and support from the Faculty Development Fund of Illinois Wesleyan University.

References

Messenger (1991). "Recovery of (878) Mildred" **64**, 55

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

Nicholson, S. and Shapley, H. (1916). “The Orbit and Probable Size of a Very Faint Asteroid” Astron. Journal **710**, 127.

Warner, B.D., Harris, A.W., and Pravec, P. (2010). Asteroid Lightcurve Data File, *http://www.MinorPlanetObserver.com/astlc/LightcurveParameters.htm.*

THE LIGHTCURVE OF JOVIAN TROJAN ASTEROID 884 PRIAMUS

Linda M. French
Department of Physics
Illinois Wesleyan University
P. O. Box 2900
Bloomington, IL 61702 USA
lfrench@iwu.edu

Robert D. Stephens
Goat Mountain Astronomical Research Station (GMARS)
Rancho Cucamonga, CA USA

Susan M. Lederer
NASA JSC/Cal State Univ. San Bernardino
Houston, TX USA

Derrick A. Rohl
Illinois Wesleyan University
Bloomington, IL USA

(Received: 15 October)

Observations of Jovian Trojan Asteroid 884 Priamus in July and August 2010 yield a symmetrical lightcurve with a period of 6.8605 ± 0.0005 h and an amplitude of 0.24 mag.

The Jovian Trojan asteroids are found in orbits near the stable L4 and L5 Lagrange points of Jupiter’s orbit. As of 29 September 2010, 2791 had been found in the L4 (preceding) region and 1732 in the L5 region.

As yet, the rotation properties of Trojan asteroids are poorly known relative to those of main belt asteroids, due to the low albedo and greater distance of the Trojans. No rotation period has been reported for 884 Priamus; Hartmann *et al.* (1988) reported a lower limit to the lightcurve amplitude of 0.37 mag., but did not publish a rotation period or a lightcurve. One of us (LF) had attempted observations of Priamus in 1987 on two successive nights which showed identical-looking fragments of a lightcurve. This suggested aliasing might be present (see the following discussion).

Observations at CTIO (Cerro Tololo Interamerican Observatory, MPC 807) were made with the CTIO 0.9-m telescope. The NOAO CFCCD camera has a field of view of 13.5’ on a side. At 0.401” per pixel, a quarter-chip configuration was used to yield 1024 x 1024-pixel images with a read noise of 3.5 and a gain of 1.5. All images taken at CTIO were unbinned; V and R filters were used. Data analysis was carried out using IRAF and MPO Canopus. Period analysis was done using Canopus, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (1989).

The results are summarized in the accompanying plot of all the lightcurve data. The plot is phased so that the data range from 0.0 to 1.0 of the best-fit period. Night-to-night calibration of the data (generally less than ±0.05 mag) was done using field stars converted to approximate Cousins R magnitudes based on 2MASS J-K colors (Warner 2007, Stephens 2010).

As mentioned previously, fragmentary observations from two successive nights in 1987 looked identical, suggesting that aliasing might be present. The best-fit period, 6.8605 ± 0.0005 h, is quite close to the period one would observe for an asteroid rotating 3.5 times in 24 hours, 6.8571 h. Observations on three nights, two of them closely spaced, were necessary to determine the period adequately.

By chance, the three observing dates found the asteroid at very nearly the same phase angle, although the July date was before opposition and the August dates after. Since some Trojans do not show the opposition effect implied by the standard IAU value of G = 0.150 for dark asteroids (French 1987; Shevchenko *et al.* 2009), we have chosen not to assume a value for G and have left the lightcurve in terms of relative magnitudes. In the future we will observe Priamus at a wider range of phase angles in order to see whether it shows the same unusual phase behavior as other Trojans.

Acknowledgements

The authors were visiting astronomers at Cerro Tololo Interamerican Observatory, National Optical Astronomy Observatory, operated by the Association of Universities for Research in Astronomy, under contract with the National Science Foundation. The Cerro Tololo 0.9-m telescope is operated by the SMARTS Consortium. This research was supported by Cottrell College Science Award grants from the Research Corporation (LF and DR; SL), support from the Lunar and Planetary Institute (SL), and support from the Faculty Development Fund of Illinois Wesleyan University (LF and RS).

References

French, L.M. (1987). “Rotation Properties of Four Trojan Asteroids from CCD Photometry.” *Icarus* **72**, 325-341.

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

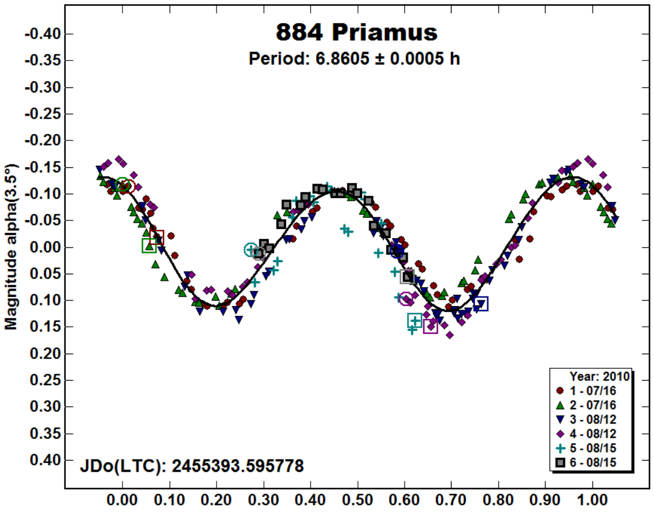
Hartmann, W., *et al.* (1988). “Trojan and Hilda asteroid lightcurves. I - Anomalously elongated shapes among Trojans (and Hildas?).” *Icarus* **73**, 487-498.

Shevchenko, V. G.; Krugly, Yu. N.; Belskaya, I. N.; Chiorny, V. G.; Gaftonyuk, N. M.; Slyusarev, I. G.; Tereschenko, I. A.; Donchev, Z.; Ivanova, V.; Borisov, G.; Ibrahimov, M. A.; Marshalkina, A. L.; and Molotov, I. E.. (2009). “Do Jupiter Trojans Have the Brightness Opposition Effect?” *Abst. LPSC* 1391.

Stephens, R. D. (2010). “Trojan Asteroids Observed from GMARS and Santana Observatories: 2009 October-December.” *Minor Planet Bul.* **37**, 47-48.

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

U.T. Date	Phase Angle
16 July 00:00	3.5°
12 August 00:00	2.8°
15 August 00:00	3.5°



LIGHTCURVE ANALYSIS OF 2261 KEELER

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

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

Donald P. Pray
Carbuncle Hill Observatory
W. Brookfield, MA USA

Russ Durkee
Shed of Science Observatory
Minneapolis, MN USA

Adrián Galád
Modra Observatory,
Department of Astronomy, Physics of the Earth, and Meteorology
Bratislava, SLOVAKIA
and
Astronomical Institute AS CR, 251 65 Ondřejov,
CZECH REPUBLIC

(Received: 14 July)

A collaborative effort to obtain CCD photometric observations of the Phocaea asteroid, 2261 Keeler, was conducted during 2010 April. We found a low amplitude lightcurve with a favored synodic period of 22.810 ± 0.005 h, but one-half this period is not ruled out.

Independent observations of Phocaea asteroid 2261 Keeler were started by Warner and Durkee in 2010 April. Durkee's work was part of the Binary Asteroid Survey conducted out of the Astronomical Institute in Ondřejov (Pravec et al., 2006). The initial observations by Warner indicated a long period object and so the two joined forces with Pray and Galád, also working under the Binary Asteroid Survey, to assure maximum coverage.

The sessions from Warner, Durkee, and Pray were linked to one another using comparison star magnitudes derived from J-K 2MASS magnitudes (Warner, 2006). The combined data set from all observers was analyzed by Kušnirák. He found a best fit of 22.810 ± 0.005 h with an amplitude of 0.10 ± 0.01 mag. However, due to the uncertainties in the nightly zero points using the 2MASS converted magnitudes, it was not possible to exclude a half period solution of ~11.4 h. Unfortunately, the next opposition (2011 September) will be about 160° different in phase angle bisector longitude, meaning that the amplitude of the curve may not be much different since the viewing aspect is about the same, save that we'll be seeing the opposite pole. It won't be until 2012 November that we'll get a viewing aspect at about right angles to the one in 2010 and, maybe, a larger amplitude curve which would make finding the true period more certain.

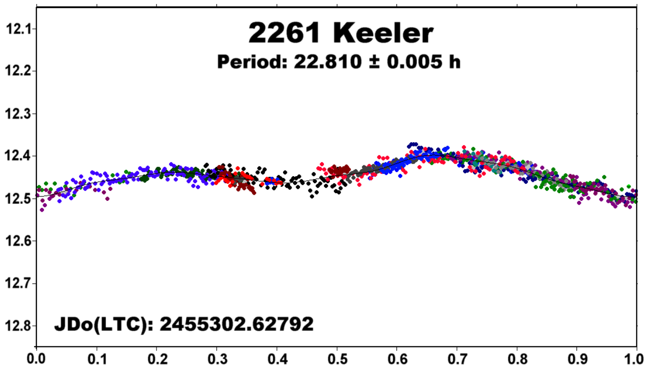
Acknowledgements

Funding for Warner is provided by NASA grant NNX10AL35G and by National Science Foundation grant AST-1032896. Warner also acknowledges a 2007 Gene Shoemaker NEO Grant from the Planetary Society. Durkee and Pray also acknowledge Shoemaker NEO Grants from The Planetary Society. The work at Ondřejov was supported by the Grant Agency of the Czech Republic, Grant 205/09/1107. The work at Modra was supported by the Slovak Grant Agency for Science VEGA, Grant 2/0016/09. 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.

References

Pravec, P., Scheirich, P., Kušnirák, P.; Šarounová, L.; Mottola, S.; Hahn, G.; Brown, P.; Esquerdo, G.; Kaiser, N.; Krzeminski, Z.; and 47 coauthors. (2006) "Photometric survey of binary near-Earth asteroids." *Icarus* **181**, 63-93.

Warner, B.D. (2006). "Initial Results of a Dedicated H-G Project" *Minor Planet Bul.* **34**, 113-119.



ASTEROID-DEEPSKY APPULSES IN 2011

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

(Received: 2 October)

The following list is a very small subset of the results of a search for asteroid-deepsky appulses for 2011, presenting only the highlights for the year based on close approaches of brighter asteroids to brighter DSOs. The complete set of predictions is available at:
http://www.minorplanetobserver.com/Misc/DSOAppulses.htm

For any event not covered, the Minor Planet Center's web site at *http://scully.harvard.edu/~cgi/CheckMP* allows you to enter the location of a suspected asteroid or supernova and check if there are any known targets in the area.

The table gives the following data, with potentially attractive astrophotography appulses indicated in **bold**:

Date/Time	Universal Date (MM DD) and Time of closest approach
#/Asteroid	The number and name of the asteroid
RA/Dec	The J2000 position of the asteroid
AM	The approximate visual magnitude of the asteroid
Sep/PA	The separation in arcseconds and the position angle from the DSO to the asteroid
DSO	The DSO name or catalog designation
DM	The approximate total magnitude of the DSO
DT	The type of DSO: OC = Open Cluster; GC = Globular Cluster; G = Galaxy
SE/ME	The elongation in degrees from the sun and moon respectively
MP	The phase of the moon: 0 = New, 1.0 = Full. Positive = waxing; Negative = waning

Date	UT	#	Name	RA	Dec	AM	Sep	PA	DSO	DM	DT	SE	ME	MP
01 01	17:37	237	Coelestina	06 43.30	+27 02.8	13.3	299	15	NGC 2266	9.5	OC	176	149	-0.07
01 01	20:42	375	Ursula	04 51.12	+43 41.7	12.5	21	149	NGC 1664	7.6	OC	148	160	-0.07
01 01	20:45	565	Marbachia	05 35.17	+09 50.6	13.9	328	169	Cr 69	2.8	OC	158	160	-0.07
01 02	19:15	563	Suleika	05 03.43	+23 44.9	11.2	281	210	NGC 1746	6.1	OC	155	174	-0.03
01 03	08:27	128	Nemesis	12 25.25	+04 50.8	13.0	316	187	NGC 4378	11.7	G	99	87	-0.01
01 05	01:20	695	Bella	02 03.46	+23 59.7	13.4	283	205	UGC 1551	12.5	G	112	104	0.01
01 07	11:28	250	Bettina	12 58.04	+01 33.1	13.1	124	204	NGC 4845	11.2	G	94	128	0.09
01 28	01:47	148	Gallia	09 55.09	+09 19.9	11.7	349	48	NGC 3049	12.1	G	160	89	-0.33
02 02	03:48	71	Niobe	13 28.99	-33 10.6	11.4	89	244	NGC 5161	11.2	G	99	90	-0.01
02 05	19:40	44	Nysa	09 40.59	+14 57.5	9.0	169	29	NGC 2954	12.4	G	174	155	0.07
02 06	13:40	89	Julia	09 38.11	+09 36.4	10.6	327	1	NGC 2939	12.4	G	172	148	0.11
02 25	19:37	128	Nemesis	12 23.72	+07 04.5	12.2	36	31	NGC 4342	12.5	G	153	75	-0.41
02 25	**20:05**	**628**	**Christine**	**12 19.07**	**+14 28.3**	**13.2**	**204**	**47**	**M99**	**9.9**	**G**	**154**	**80**	**-0.41**
02 27	14:51	124	Alkeste	07 36.58	+17 56.3	12.5	155	27	NGC 2418	12.2	G	134	167	-0.24
02 27	14:59	278	Paulina	12 28.31	+09 54.0	12.9	353	32	NGC 4442	10.4	G	153	97	-0.24
02 28	09:28	611	Valeria	09 42.04	+00 18.9	13.2	85	221	NGC 2967	11.6	G	163	141	-0.17
03 06	08:22	1248	Jugurtha	11 40.25	+17 42.7	13.5	86	206	NGC 3801	12.0	G	165	157	0.02
03 10	04:31	933	Susi	12 26.57	+03 57.5	13.9	45	223	NGC 4412	12.4	G	163	136	0.24
03 10	13:02	346	Hermentaria	11 17.01	+18 09.4	11.5	29	24	NGC 3608	10.8	G	166	110	0.27
03 30	21:20	250	Bettina	12 38.16	+01 23.2	11.8	291	188	NGC 4581	12.5	G	175	140	-0.12
04 02	08:57	231	Vindobona	17 46.30	-29 23.0	13.8	311	194	Cr 347	8.8	OC	105	92	-0.01
04 02	16:00	390	Alma	13 07.33	-28 10.0	13.9	180	8	NGC 4965	12.1	G	156	152	-0.01
04 08	19:06	134	Sophrosyne	13 25.30	-21 07.5	12.6	27	187	NGC 5134	11.3	G	166	131	0.23
04 26	**00:50**	**484**	**Pittsburghia**	**15 18.59**	**+02 04.6**	**13.7**	**27**	**204**	**M5**	**5.8**	**GC**	**158**	**88**	**-0.41**
05 01	00:18	287	Nephthys	15 16.12	+00 06.2	11.2	50	24	Pal 5	11.8	GC	162	142	-0.05
05 02	01:50	983	Gunila	14 39.55	-26 32.9	13.6	70	216	NGC 5694	10.2	GC	169	161	-0.01
05 03	06:20	44	Nysa	09 38.52	+16 58.4	10.8	229	198	NGC 2943	12.4	G	99	99	0.00
05 06	08:36	256	Walpurga	14 11.64	-01 10.3	13.8	92	213	NGC 5496	12.1	G	162	130	0.09
05 07	20:17	287	Nephthys	15 09.94	+00 29.8	11.2	113	18	NGC 5869	11.9	G	162	124	0.20
05 25	**21:52**	**731**	**Sorga**	**17 01.14**	**-30 03.6**	**13.7**	**212**	**347**	**M62**	**6.6**	**GC**	**165**	**90**	**-0.39**
06 02	03:56	52	Europa	12 16.37	+07 24.5	11.7	292	224	NGC 4224	11.8	G	109	106	0.00
06 05	02:48	52	Europa	12 17.23	+07 12.6	11.7	45	42	NGC 4235	11.6	G	107	69	0.11
06 06	13:36	1244	Deira	17 16.48	-28 12.3	13.9	273	200	NGC 6316	9.0	GC	173	127	0.23
06 28	07:05	382	Dodona	17 46.96	-31 29.4	12.5	163	15	NGC 6425	7.2	OC	168	152	-0.10
06 29	01:56	511	Davida	18 18.49	-18 29.5	11.5	277	165	NGC 6603	11.1	OC	175	154	-0.06
06 30	**22:07**	**511**	**Davida**	**18 17.00**	**-18 35.3**	**11.5**	**16**	**165**	**M24**	**4.0**	**OC**	**173**	**176**	**0.00**
07 02	**18:29**	**1166**	**Sakuntala**	**18 19.85**	**-17 07.3**	**12.4**	**56**	**314**	**M18**	**6.9**	**OC**	**172**	**156**	**0.03**
07 04	01:26	462	Eriphyla	17 52.91	-22 23.0	13.2	123	175	NGC 6469	8.2	OC	167	132	0.09
07 24	04:07	1103	Sequoia	20 34.03	+07 20.1	13.9	282	213	NGC 6934	8.9	GC	152	87	-0.41
07 24	**21:08**	**834**	**Burnhamia**	**18 19.91**	**-17 08.5**	**13.0**	**32**	**165**	**M18**	**6.9**	**OC**	**153**	**134**	**-0.34**
07 27	00:34	218	Bianca	01 21.88	+05 21.8	13.6	356	12	NGC 488	10.3	G	103	56	-0.16
07 30	02:37	382	Dodona	17 28.72	-29 27.4	13.2	198	61	Tr 26	9.5	OC	136	144	-0.01
08 23	19:26	834	Burnhamia	18 16.38	-18 13.6	13.7	39	208	Cr 469	9.1	OC	124	167	-0.31
08 27	19:42	735	Marghanna	02 38.26	-01 21.2	12.5	91	143	NGC 1015	12.1	G	116	98	-0.02
08 29	10:42	834	Burnhamia	18 18.39	-18 25.6	13.8	36	199	NGC 6603	11.1	OC	119	114	0.00
08 30	18:38	488	Kreusa	02 46.31	+03 34.7	13.6	111	227	NGC 1085	12.3	G	116	137	0.04
09 01	21:59	107	Camilla	01 50.38	+06 08.9	12.9	118	296	NGC 693	12.4	G	131	171	0.20
09 24	14:57	1087	Arabis	01 20.08	+03 27.0	13.8	120	352	NGC 474	11.5	G	161	121	-0.11
09 25	00:21	1087	Arabis	01 19.79	+03 26.3	13.8	81	352	NGC 470	11.8	G	161	127	-0.09
09 26	05:29	426	Hippo	04 46.83	+44 41.4	13.8	261	127	Ru 148	9.5	OC	105	91	-0.02
09 26	23:18	441	Bathilde	06 07.53	+24 08.4	13.5	145	9	NGC 2158	8.6	OC	92	85	0.00
10 29	15:30	23200	2000 SH3	01 48.92	+12 58.0	13.9	289	213	NGC 677	12.2	G	174	135	0.11
12 18	07:18	391	Ingeborg	07 37.21	-13 54.7	13.7	186	149	NGC 2423	6.7	OC	133	63	-0.47
12 19	21:52	8345	Ulmerspatz	06 43.01	+27 00.4	14.0	207	314	NGC 2266	9.5	OC	167	103	-0.29
12 20	17:38	175	Andromache	07 58.23	+25 04.5	13.7	216	196	NGC 2487	12.5	G	151	98	-0.21
12 21	13:35	16	Psyche	11 17.55	+04 35.4	11.5	149	17	NGC 3611	12.1	G	101	58	-0.13

ASTEROID LIGHTCURVE ANALYSIS AT THE OAKLEY SOUTHERN SKY OBSERVATORY: 2010 MAY

Zachary Pligge, Adam Monnier, John Pharo, Kellen Stolze, Arnold Yim, Richard Ditteon
Rose-Hulman Institute of Technology CM 171
5500 Wabash Ave., Terre Haute, IN 47803
ditteon@rose-hulman.edu

(Received: 23 July)

Photometric data for 16 asteroids were collected over 12 nights of observing during 2010 May at the Oakley Southern Sky Observatory. The asteroids were: 295 Theresia, 500 Selinur, 1018 Arnolda, 1027 Aesculapia, 1162 Larissa, 1258 Sicilia, 1260 Walhalla, 1375 Alfreda, 1834 Palach, 3560 Chenqian, 3774 Megumi, 3991 Basilevsky, 6139 Naomi, 6838 Okuda, 9297 Marchuk, and (11549) 1992 YY.

Sixteen asteroids were observed from the Oakley Southern Sky Observatory in New South Wales, Australia, on the nights of 2010 May 4-15. From the data, we were able to find lightcurves for 12 asteroids. We could find no previously reported results for 5 of those 12. Out of the remaining objects, those with previously recorded results, 3 were consistent with previously published periods and the others were not. We could find no repeatable pattern for 4 asteroids.

Selection of asteroids for photometry was based on their sky position about one hour after sunset. Asteroids without previously published lightcurves were given higher priority than asteroids with known periods, but asteroids with uncertain periods were also selected with the hopes that we would be able to improve previous results. A 20-inch 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.

We could find no previously reported lightcurve results for 1258 Sicilia, 6139 Naomi, 6838 Okuda, 9297 Marchuk, and (11549) 1992 YY. No repeatable pattern was found for 1027 Aesculapia, 1260 Walhalla, 3774 Megumi, and 3991 Basilevsky. Our data for the latter group were too noisy for us to determine periods or were too sparse, so we are reporting the magnitude variations only. Results from all of the asteroids are listed in the table below. Additional comments have been included as needed.

295 Theresia. Our results are reasonably close to the period of 10.70 ± 0.01 h found by Menke (2005) and 10.706 h by Behrend (2010). We had only a single peak; we tried doubling the period to fit but did not have enough data.

500 Selinur. Our results are reasonably close to the period 8 h found by Behrend (2010).

1018 Arnolda. Our results are inconsistent with the period of 11.97 ± 0.01 h found by Binzel (1987), but are based on a substantially larger data set, giving a more secure result.

1162 Larissa. Our results are inconsistent with the period of 13 h found by Dahlgren (1998). We tried fitting our data to 13 h but received four peaks, which leads us to believe Dahlgren found a double period.

1375 Alfreda. Our results are inconsistent with the period of 24 h found by Behrend (2010). Warner *et al*. (2010) interpreted the sparse Behrend data as $P > 12$ h, which is borne out by our period of 19.14 h.

1834 Palach. Our results are reasonably close to the period of 3.139 ± 0.001 h found by Behrend (2010).

3560 Chenqian. Carbo *et al.* (2009) observed this asteroid in 2009 March. They were not able to find a period but did report an amplitude of 0.08 mag.

Acknowledgement

Construction of the Oakley Southern Sky Observatory was funded with a grant from the Oakley Foundation and by a generous donation from Niles Noblitt. This research was partially supported by a grant from NASA administered by the American Astronomical Society.

References

Behrend, R. (2010). Observatoire de Geneve web site, *http://obswww.unige.ch/~behrend/page_cou.html*

Number	Name	Dates 2010 mm/dd	Data Points	Period (h)	P.E (h)	Amp (mag)	A.E. (mag)
295	Theresia	5/11-13	52	10.87	0.04	0.10	0.01
500	Selinur	5/10-15	157	8.006	0.005	0.16	0.02
1018	Arnolda	5/10-15	155	14.617	0.004	0.33	0.02
1027	Aesculapia	5/10, 5/12-15	80	-	-	0.15	0.01
1162	Larissa	5/10-15	136	6.516	0.002	0.22	0.02
1258	Sicilia	5/4-6, 5/8-9	105	13.500	0.003	0.19	0.01
1260	Walhalla	5/10-15	149	-	-	0.16	0.04
1375	Alfreda	5/10-15	151	19.14	0.02	0.17	0.02
1834	Palach	5/10-15	140	3.1358	0.0009	0.14	0.01
3560	Chenqian	5/10-15	144	18.79	0.02	0.26	0.01
3774	Megumi	5/4-9	105	-	-	0.11	0.01
3991	Basilevsky	5/4-9	99	-	-	0.15	0.01
6139	Naomi	5/4-6, 5/8-9	100	21.35	0.04	0.20	0.01
6838	Okuda	5/4-9	105	8.983	0.008	0.14	0.01
9297	Marchuk	5/5-6, 5/8-9	58	18.09	0.02	0.16	0.01
11549	1992 YY	5/4-6, 5/8-9	94	2.671	0.002	0.07	0.01

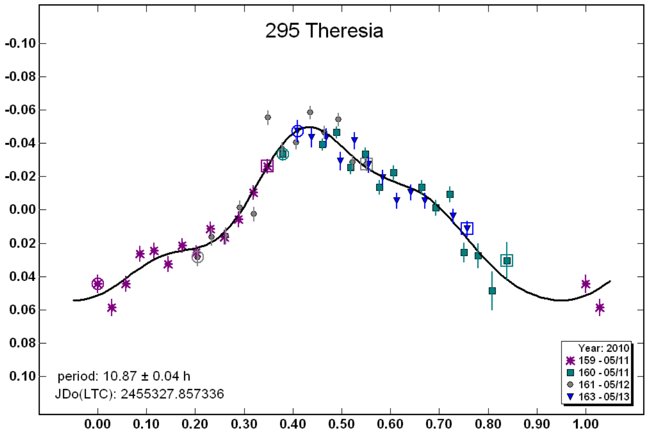
Binzel, R.P. (1987). “A photoelectric survey of 130 asteroids.” *Icarus* **72**, 135-208

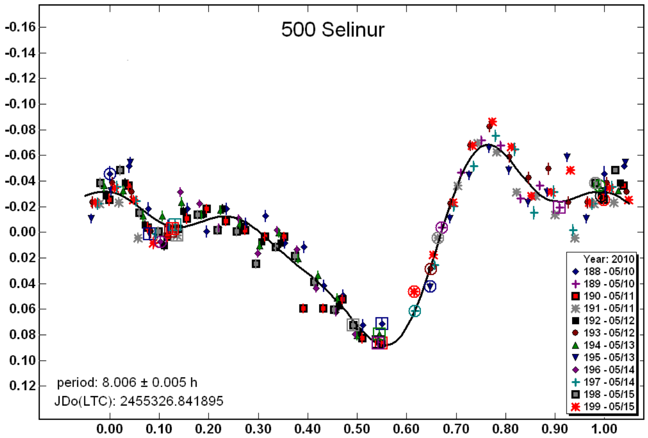
Carbo, L., Green, D., Kragh, K., Krotz, J., Meiers, A., Patino, B., Pligge, Z., Shaffer, N., and Ditteon, R. (2009). “Asteroid Lightcurve Analysis at the Oakley Southern Sky Observatory: 2008 October thru 2009 March.” *Minor Planet Bul.* **36**, 152-157.

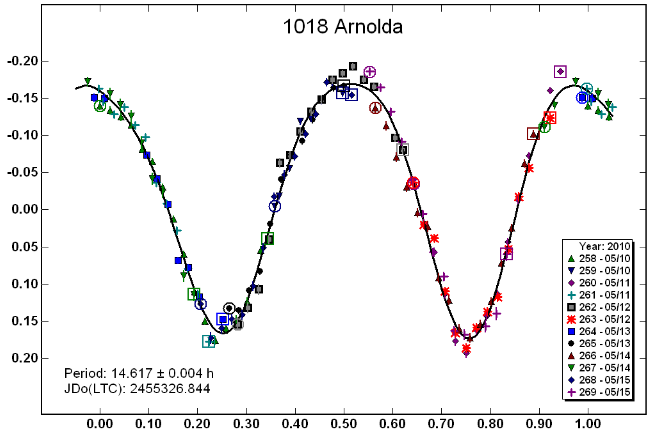
Dahlgren, M. (1998). “A Study of Hilda Asteroids.” *Icarus* **133**, 247-285

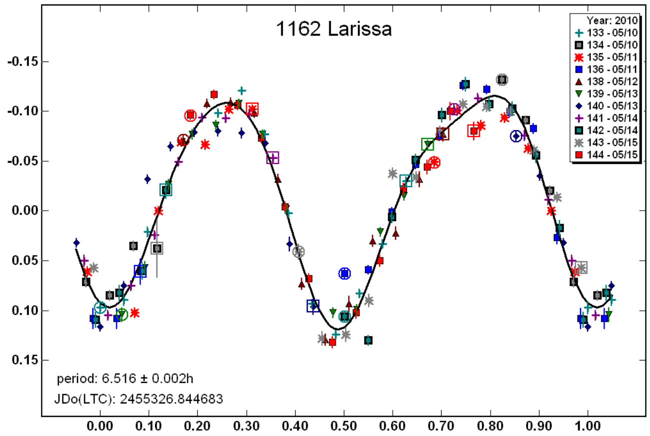
Menke, J. (2005). “Asteroid lightcurve results from Menke Observatory.” *Minor Planet Bul.* **32**, 85-88.

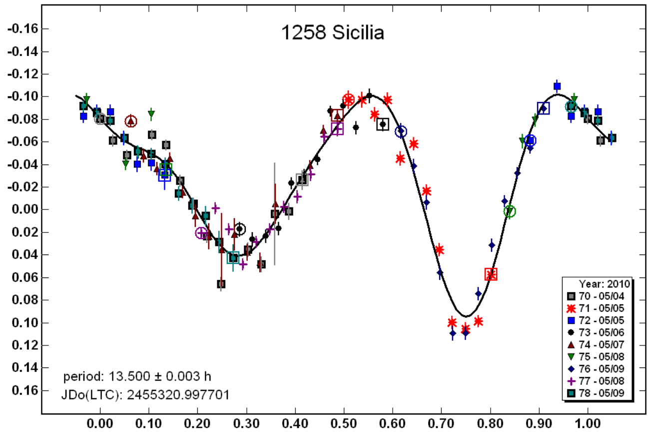
Warner, B.D., Harris, A.W., and Pravec, P. (2010). *Asteroid Lightcurve Database*. On-line version, available at *http://MinorPlanetObserver.com/astlc/default.htm*

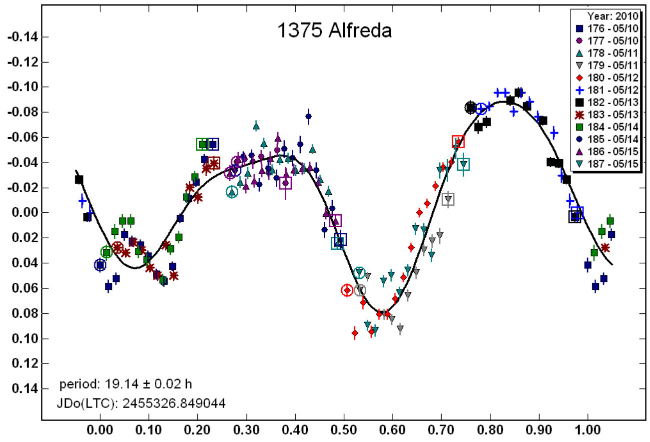


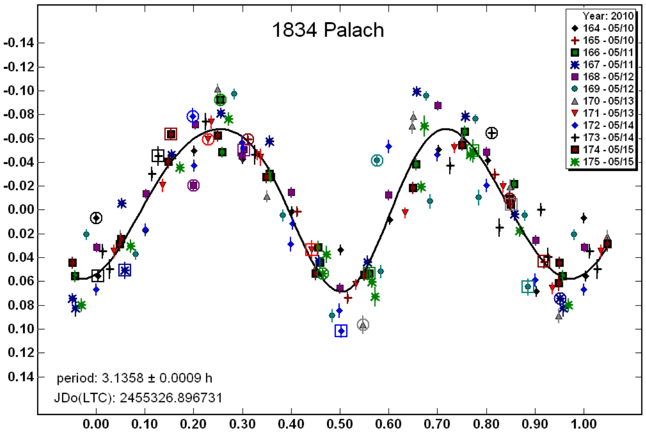


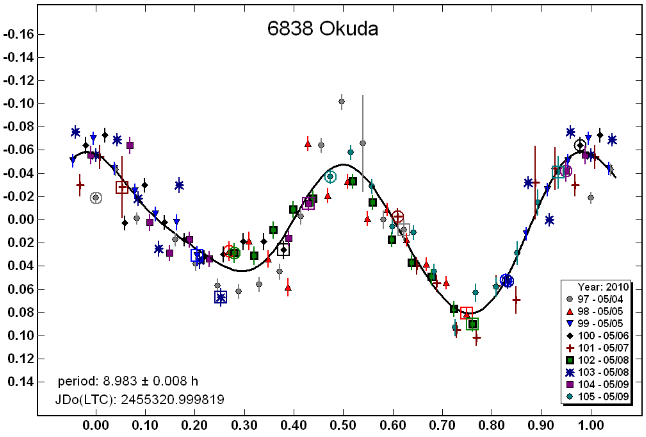


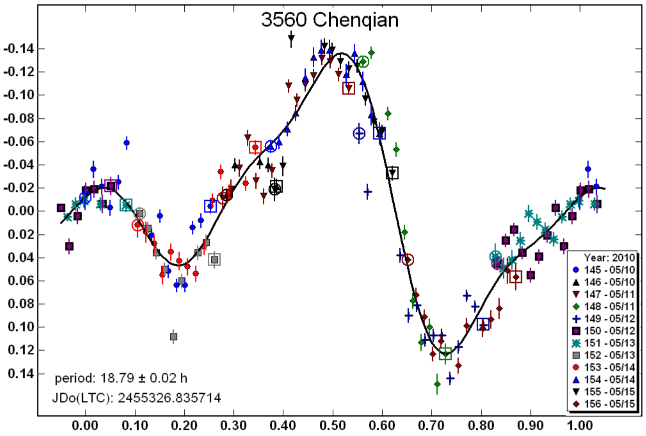


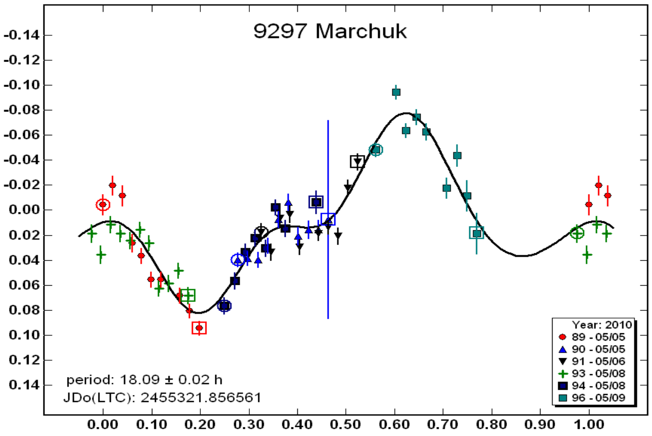


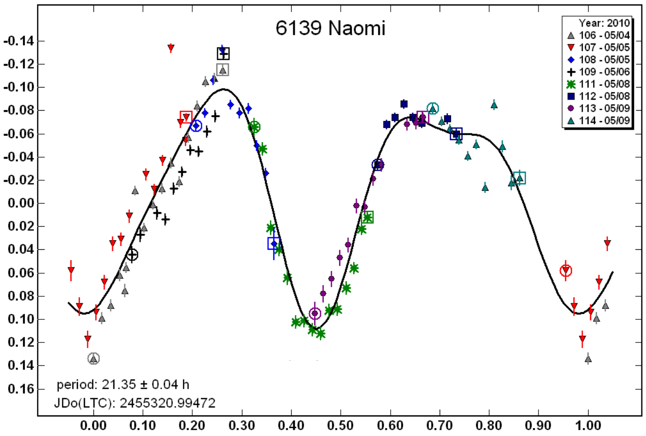


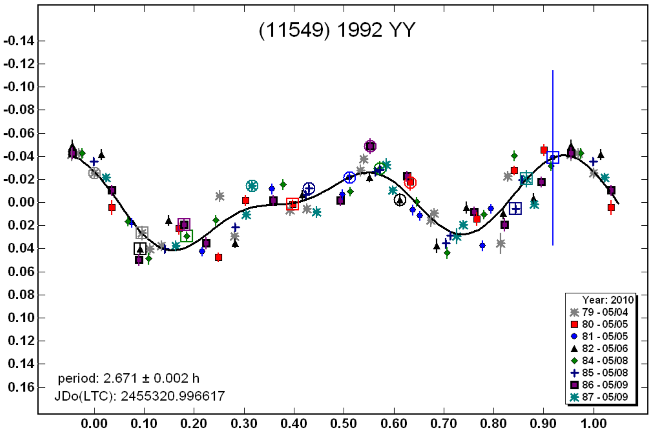

1834 Palach
Year: 2010
164 - 05/10
165 - 05/10
166 - 05/11
167 - 05/11
168 - 05/12
169 - 05/12
170 - 05/13
171 - 05/13
172 - 05/14
173 - 05/14
174 - 05/15
175 - 05/15
period: 3.1358 ± 0.0009 h
JDo(LTC): 2455326.896731
-0.14
-0.12
-0.10
-0.08
-0.06
-0.04
-0.02
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


6838 Okuda
Year: 2010
97 - 05/04
98 - 05/05
99 - 05/05
100 - 05/06
101 - 05/07
102 - 05/08
103 - 05/08
104 - 05/09
105 - 05/09
period: 8.983 ± 0.008 h
JDo(LTC): 2455320.999819
-0.16
-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


3560 Chenqian
Year: 2010
145 - 05/10
146 - 05/10
147 - 05/11
148 - 05/11
149 - 05/12
150 - 05/12
151 - 05/13
152 - 05/13
153 - 05/14
154 - 05/14
155 - 05/15
156 - 05/15
period: 18.79 ± 0.02 h
JDo(LTC): 2455326.835714
-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


9297 Marchuk
Year: 2010
89 - 05/05
90 - 05/05
91 - 05/06
93 - 05/08
94 - 05/08
96 - 05/09
period: 18.09 ± 0.02 h
JDo(LTC): 2455321.856561
-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


6139 Naomi
Year: 2010
106 - 05/04
107 - 05/05
108 - 05/05
109 - 05/06
111 - 05/08
112 - 05/08
113 - 05/09
114 - 05/09
period: 21.35 ± 0.04 h
JDo(LTC): 2455320.99472
-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
0.16
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


(11549) 1992 YY
Year: 2010
79 - 05/04
80 - 05/05
81 - 05/05
82 - 05/06
84 - 05/08
85 - 05/08
86 - 05/09
87 - 05/09
period: 2.671 ± 0.002 h
JDo(LTC): 2455320.996617
-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
0.16
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

CCD LIGHTCURVES FOR 4 MAIN BELT ASTEROIDS

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

(Received: 25 July)

Unfiltered CCD-derived lightcurves for 93 Minerva, 287 Nephthys, 665 Sabine, and 762 Pulcova produced synodic period solutions by Fourier analyses for all objects except for 93 Minerva.

UnderOak Observatory (UO) is a privately-operated backyard observatory located in north-central New Jersey. The primary instrument is a 0.2-m catadioptric OTA (f/9) equipped with an SBIG ST402ME thermoelectrically-cooled CCD. The optical configuration, acquisition conditions, and image calibration/ registration methods have been previously described (Alton, 2010). Unfiltered 45-s exposures were continually captured during each session. Final data reduction with *MPO Canopus* (Warner, 2008) used at least 3 non-varying comparison stars for each object to generate lightcurves by differential aperture photometry. In all but one case, Fourier analysis (Harris *et al.*, 1989) yielded a period solution from each dataset. Period solutions (or lack thereof) were independently verified using *Peranso* (Vannmunster, 2006) by applying periodic orthogonals (Schwarzenberg-Czerny, 1996) to fit observations and analysis of variance to evaluate fit quality. Data were light-time corrected but not reduced to standard magnitudes. Relevant aspect parameters for each of these main belt asteroids (MBA) taken at the mid-point from each observing session are tabulated below. Phased data are available by request at http://underoakobservatory.com.

93 Minerva. This 142 km C-type asteroid was recently discovered to be a triple system (Marchis, 2009). In all, 1347 images were taken over six nights between 2009 Nov 8 and Dec 02 and reduced to instrumental magnitudes by ensemble photometry. In this case, lightcurve analysis was seeded using the synodic period (5.982 h) posted at the JPL Solar System Dynamics website. Overall, the resulting lightcurve was largely featureless and no meaningful period solution could be derived. Shape modeling by Torppa *et al.* (2008) revealed remarkable axial symmetry (b/a = 0.99 and c/b = 0.97). As would be expected, published lightcurves for Minerva rarely have amplitudes $A > 0.1$ mag.

287 Nephthys. This is believed to be an S-type asteroid with D = 68 km. A set of 1105 images was acquired on five nights between 2010 Feb 01 and Mar 08. The synodic period solution (7.6041 ± 0.00002 h) estimated by *MPO Canopus* was consistent with a previous determination by Alton (2008) and others referenced at the JPL Solar System Dynamics website. The amplitude of A = 0.41 mag from this data set was slightly larger than observed at the previous apparition in 2007 May (A = 0.36 mag).

665 Sabine. This intermediate-sized MBA (D = 51 km) has a rather high albedo of p_v = 0.39. A total of 829 images captured over 4 nights between 2009 Oct 22 and Nov 04 were used to produce a lightcurve and find a synodic period solution. The calculated period (4.294 ± 0.0001 h) was identical to that reported by Ditteon and Hawkins (2007) for a 2006 Nov data set and very close to that posted at the JPL Solar System Dynamics website (4.29 h). The amplitude of A = 0.55 mag in 2009 Oct-Nov exceeded that from 2006 Nov, A = 0.5 mag.

762 Pulcova. This somewhat uncommon F-type minor planet (D = 137 km) is another MBA discovered to be a binary system during the past decade (Merline *et al.*, 2000). Its satellite (D ~20 km) revolves around the primary every 4.44 d. A total of 754 images was collected during 3 sessions between 2009 Nov 29 and Dec 17 and reduced to generate a single phased lightcurve. Fourier analysis uncovered a synodic period of 5.839 ± 0.0001 h, which was identical to that posted on the JPL Solar System Dynamics website. The amplitude of the lightcurve, A = 0.38 mag, was nearly twice that observed in 2006 Mar by Oey (2006). Significant but seemingly correlated scatter is noted in the folded lightcurve (*phase* = 0.75) that is also observed in each of two different sessions separated by ~5 d. It is unknown whether this behavior is related to the binary nature of this asteroid.

Acknowledgement

Many thanks to the Jet Propulsion Laboratory for providing a friendly public interface via the Solar System Dynamics small-body database browser to a wealth of minor planet data and orbital simulations.

References

Alton, K.B. (2008). “Lightcurve Analysis of 287 Nephthys.” *Minor Planet Bulletin* **35**, 33-34.

Alton, K.B. (2010). “A Unified Roche-Model Light Curve Solution for the W UMa Binary AC Bootis.” *JAAVSO* **38**.

Ditteon, R. and Hawkins, S. (2007). “Asteroid Lightcurve Analysis at the Oakley Observatory – October-November 2006.” *Minor Planet Bulletin* **34**, 59-64.

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

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

Marchis, F. (2009). “The discovery of a new triple asteroid - (93) Minerva.” Cosmic Diary Blog.
http://www.cosmicdiary.org/blogs/nasa/franck_marchis/?p=465.

Asteroid	Range Over Observation Period			
	UT Date	Phase Angle	L_{PAB}	B_{PAB}
93 Minerva	2009 Nov 8 - 2009 Dec 2	9.9 - 16.5	21.8 - 23.2	+4.1 - +4.6
287 Nephthys	2010 Feb 1 - 2010 Mar 8	18.2 - 24.1	92.0 - 98.0	-8.3 - -6.0
665 Sabine	2009 Oct 22 - 2009 Nov 4	15.9 - 17.5	340.4 - 341.9	+13.0 - +13.0
762 Pulcova	2009 Nov 29 - 2009 Dec 17	10.9 - 14.9	39.4 - 40.3	+15.5 - +14.8

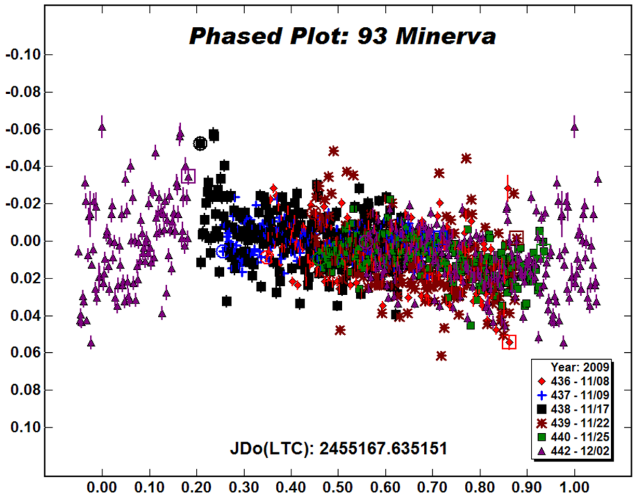
Merline, W.J., Close, L.M., Dumas, C., Shelton, J.C., Menard, F., Chapman, C.R., and Slater, D.C. (2000). "Discovery of Companions to Asteroids 762 Pulcova and 90 Antiope by Direct Imaging." *Bulletin of the American Astronomical Society* **32**, 1017.

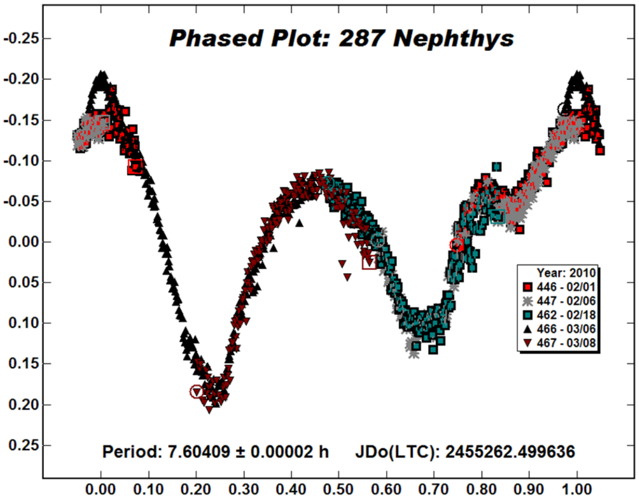
Schwarzenberg-Czerny, A. (1996). "Fast and Statistically Optimal Period Search in Uneven Sampled Observations." *Astrophys J.* **460**, L107.

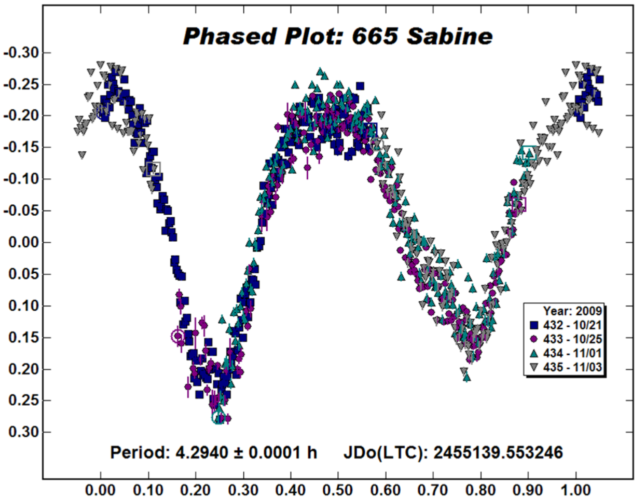
Torppa, J., Hentunen, V.-P., Pääkkönen, P., Kehusmaa, P., and Muinonen, K. (2008). "Asteroid shape and spin statistics from convex models." *Icarus* **198**, 91-107.

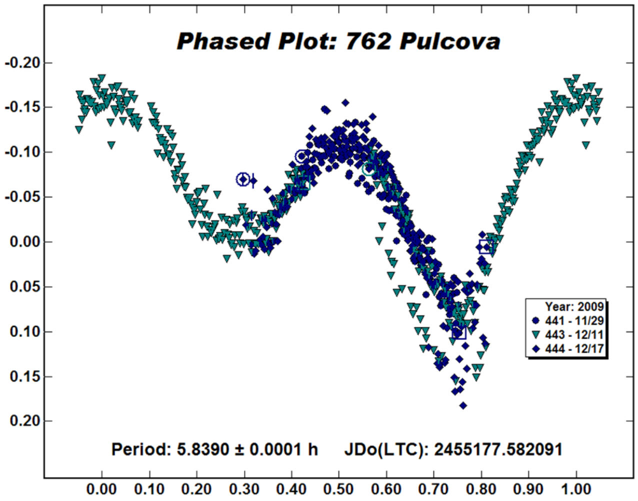
Vannmunster, T. (2006). *Peranso* Period Analysis Software, version 2.31. CBA Belgium Observatory.

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









LIGHTCURVES FOR 869 MELLENA, 2375 RADEK, AND (19261) 1995 MB

Larry E. Owings
Barnes Ridge Observatory
23220 Barnes Lane
Colfax, CA 95713 USA
lowings@foothill.net

(Received: 24 August)

CCD observations have yielded lightcurve period determinations for the following asteroids: 869 Mellena, 6.510 ± 0.001 h; 2375 Radek, 16.877 ± 0.002 h; and (19261) 1995 MB, 4.5911 ± 0.0008 h.

Photometric data were collected at Barnes Ridge Observatory in northern California, USA, using a 0.43-m f/6.8 Planewave CDK17 and Apogee U9 camera. The camera was binned 2x2 with a resulting image scale of 1.26 arc-seconds per pixel. All images were taken through a clear filter with exposures of 120 seconds at –25°C. The images were obtained with *MaxIm DL* V5 driven by *ACP* v5 and then analyzed using *MPO Canopus* v10.0 (Warner, 2010). All comparison stars and asteroid targets had SNR > 200.

869 Mellena. Data were collected from 2010 June 07-15 resulting in 4 data sets totaling 340 data points. 869 Mellena was tracked through 30.15 revolutions of the adopted period of 6.510 ± 0.001 h. The lightcurve amplitude was 0.20 mag. The period agrees with those posted independently by R.D. Stephens, A. Ferrero, and A. Carbognani on the CALL web site pending formal publication (*http://www.MinorPlanetObserver.com/astlc/default.htm*).

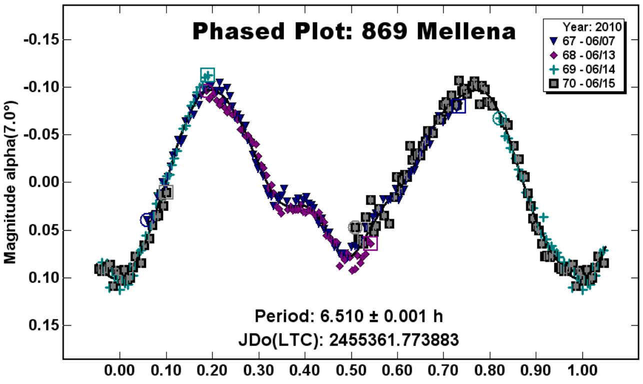
2375 Radek. Data were collected from 2010 April 25 through May 08 resulting in 4 data sets totaling 233 data points. A period of 16.877 ± 0.002 h was determined with an amplitude of 0.16 mag. This agrees with the period found by Benishek and Pilcher (2010).

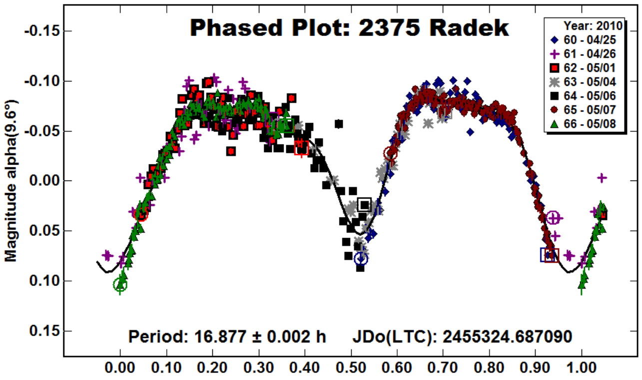
(19261) 1995 MB. Data were collected from 2010 July 12-14 resulting in 3 data sets totaling 296 data points. A period of 4.5911 ± 0.0008 h was determined with an amplitude of 0.52 mag. This is slightly different from the period of 4.586 h posted by A. Carbognani on the CALL web site pending formal publication.

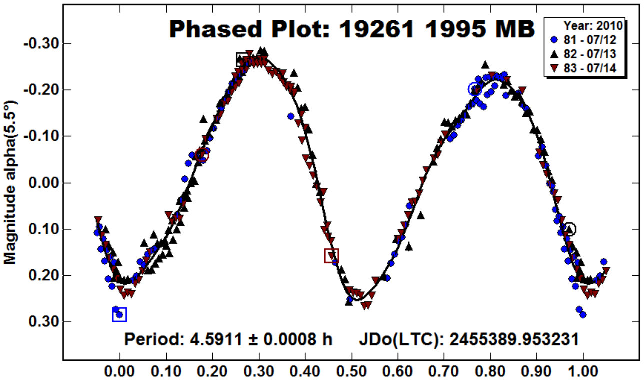
References

Benishek, V. and Pilcher, F. (2010). “Rotation Period Determination for 2375 Radek.” *Minor Planet Bul.* **37**, 166.

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







LIGHTCURVE FOR NEAR-EARTH ASTEROID (164400) 2005 GN59

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

(Received: 25 August Revised: 2 November)

CCD observations of near-Earth asteroid (164400) 2005 GN59 were used to determine its lightcurve parameters of P = 38.62 ± 0.01 h and A = 1.34 ± 0.05 mag.

Selection of (164400) 2005 GN59 was made from the quarterly lightcurve photometry opportunities article published in *The Minor Planet Bulletin* (Warner *et al.*, 2008). Even though this was a favorable apparition for this near-Earth asteroid, it was a relatively faint target, ranging from V = 14.1 to 16.7, and visible at least four hours each night from 2008 August 20 to September 26. The angular sky rate ranged from 1.06 to 7.03 arcseconds per minute during this period. Observations were made with a 0.36-m Celestron Schmidt-Cassegrain working at f/5.5 and an SBIG ST-10XME camera that was binned 2x2, resulting in a scale of 1.3 arcseconds/pixel. The camera was run at -15C. The exposures were 60 s using a clear filter. No guiding was necessary. A total of 202 images were taken and used for period analysis. The nightly data were reduced using *MPO Canopus* (Bdw Publishing, 2010).

The analysis of the combined data set indicated a probable period of 38.62 ± 0.01 h. No previously reported lightcurve parameters were found in the asteroid Lightcurve Database (LCDB, Warner *et al.*, 2009). Examination of the period solution gives near equal probability for a monomodal solution of 19.31 ± 0.01 h as well. However, the large amplitude and relatively low phase angle virtually assure a bimodal solution

Acknowledgments

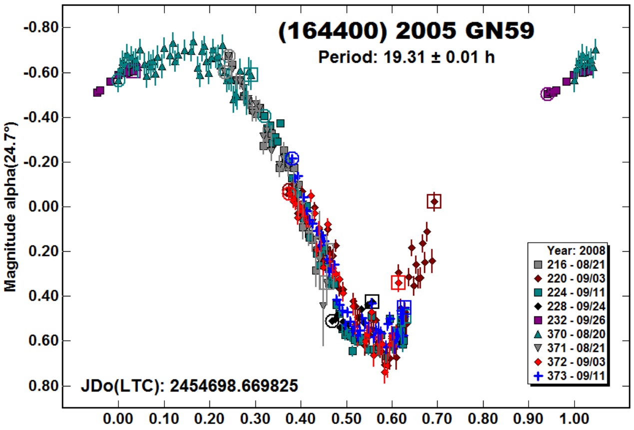
The author appreciates the assistance of Brian Warner in better understanding the tricky process of long period analysis.

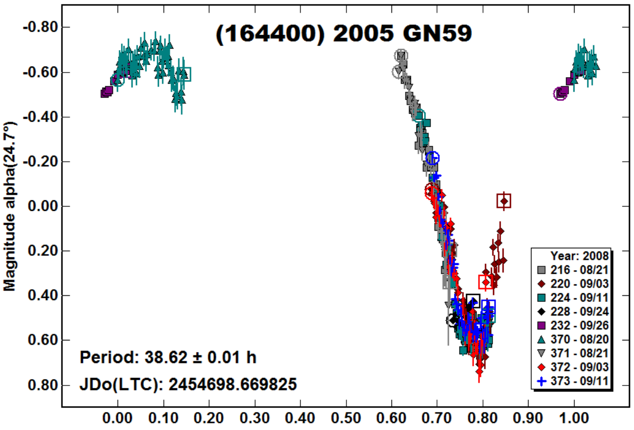
References

Bdw Publishing (2010). *MPO Canopus*, version 10.0.0.7. *http://minorplanetobserver.com/*

Warner, B.D., Harris, A.W., and Pravec, P. (2009). "The asteroid lightcurve database." *Icarus* **202**, 134-146.

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





LIGHTCURVE ANALYSIS OF ASTEROIDS 664 JUDITH AND (20453) 1999 KL6

Matthew Hosek
Williams College
331 Lexington St, Ballston Spa NY 12020
mwh3@williams.edu

William J. Cooke
NASA Marshall Space Flight Center
Meteoroid Environment Office
NASA/MSFC/EV44, Huntsville AL 35812

Robert M. Suggs
NASA Marshall Space Flight Center
Space Environments Team
NASA/MSFC/EV44, Huntsville AL 35812

(Received: 6 September)

Presented are the lightcurves of main-belt asteroids 664 Judith and (20453) 1999 KL6 obtained from observations between 2010 July and August. We found the synodic rotation period of 664 Judith to be 10.68 ± 0.00051 h with amplitude 0.18 ± 0.04 mag in the Johnson V filter, refining previously reported values. For (20453) 1999 KL6, which did not have a previously published lightcurve, we report a synodic rotation period of 3.911 ± 0.0005 h with amplitude 0.12 ± 0.04 mag in the Johnson R filter.

We observed main-belt asteroids 664 Judith and (20453) 1999 KL6 between 2010 July and August using two telescopes located at New Mexico Skies in New Mexico, USA. Both telescopes were controlled remotely via Internet connection from the Marshall Space Flight Center (MSFC). 664 Judith was observed primarily with time purchased on the Global Rent-a-scope (GRAS) 0.25-meter f/3.4 Tak Epsilon 250 telescope (designated GRAS-004) equipped with an SBIG ST-8XE CCD camera with a 1528x1528 array of 6.8 micron pixels. Binning was set to 1x1, which gave an image scale of 1.66 arcseconds/pixel. Observations of 664 Judith were taken through the Johnson V filter with an exposure time of 300 seconds. Supplementary observations of this asteroid as well as all observations of (20453) 1999 KL6 were recorded using Marshall Space Flight Center's RCOS 0.5-meter f/8.1 Ritchey-Chretien telescope on a German equatorial mount. The CCD camera used was an SBIG ST-10XME system with a 2184x1472 array of 6.8 micron pixels. Due to atmospheric seeing constraints, the camera was operated at 3x3 binning, creating a 728x490 array of 20.4 micron pixels with an image scale of 1.03 arcseconds/pixel. 664 Judith was observed using the Johnson V filter with an exposure time of 100 seconds. Observations of (20453) 1999 KL6 used the Johnson R filter with exposure times of 240 seconds. All images were appropriately dark subtracted and flat fielded.

These asteroids were chosen from the list of "Potential Lightcurve Targets for 2010 July-September" on the CALL website (Warner, 2010a). Several factors were taken into account in the selection; these included sky position, predicted magnitude, favorability of opposition, and existence of previously reported lightcurve data. (664) Judith was chosen because its lightcurve parameters had already been reported to some accuracy (a "2" on the U-code, as defined on the CALL website), allowing us to establish and test our data processing procedure. (20453) 1999 KL6 was chosen for the opposite reason, i.e., its lightcurve parameters were unknown. Both asteroids were predicted to have a magnitude V < 16, so they would be detectable with our telescope systems.

Differential photometric analysis was performed using *MPO Canopus* software (Warner, 2010b). Because both asteroids were passing through crowded star fields at the time of observation, each image was carefully checked for possible appulses with background stars that would render photometric measurements inaccurate. Light-time, distance, and phase angle corrections were automatically calculated and applied using the appropriate parameters in the Minor Planet Center asteroid database. Period analysis was also done in *MPO Canopus* using the FALC algorithm developed by Harris (Harris *et al*., 1989).

664 Judith. We observed the asteroid for a total of sixteen nights, ten nights (from 2010 July 5-23) using the GRAS 0.25-meter telescope followed by six nights (from 2010 July 28-August 15) using the MSFC 0.5-meter telescope. Four of the sixteen nights required multiple photometry sessions in *MPO Canopus* in order to change measurement aperture sizes to adjust for the broadening of the object's full width half max (FWHM) as the airmass of the observations increased. This separation allowed us to use a smaller-sized aperture for low airmass observations, decreasing the possibility of appulse, while still making accurate measurements with a larger-sized aperture at high airmasses. The lightcurve has a period of 10.6829 ± 0.0005 h with amplitude 0.18 ± 0.04 mag, revising the previously published period of 10.76 ± 0.14 hours (Degraff *et al*., 2002).

(20453) 1999 KL6. Observations recorded over ten nights were combined to create the lightcurve for this object. Seven of the ten nights used multiple photometry sessions in *MPO Canopus* to account for broadening FWHM with increasing airmass, just as with 664 Judith. The lightcurve suggests a synodic rotation period of 3.9112 ± 0.0005 h with amplitude 0.12 ± 0.04 mag in the Johnson R filter.

Acknowledgements

The authors would like to thank the NASA Undergraduate Student Research Program and the Meteoroid Environment Office for funding Hosek during his summer internship. They would also like to thank Eric Ramesh of New Mexico State University for his help with the *MPO Canopus* software, and Arnie Rosner of Global-Rent-a-scope for his technical support during the observation period.

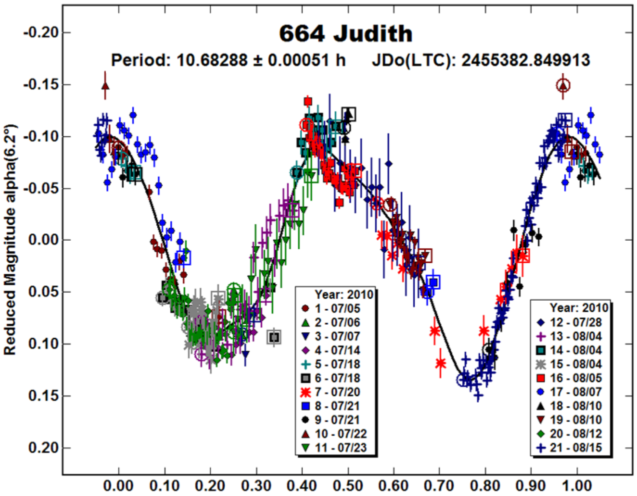
References

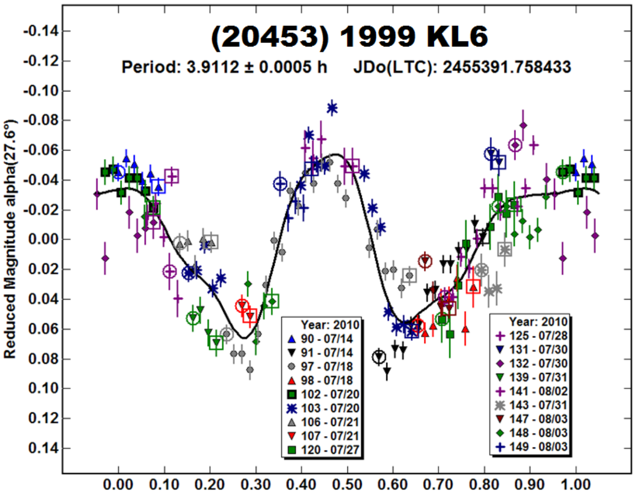
Degraff, D.R., Robbins, A.M., and Gutermuth, R.A. (2002). "Differential Photometry for Six Asteroids: 664, 1084, 2038, 2595, 3227, and 2357." *Newsletter of the Astronomical Society of NY*, Vol. 5, No. 7, pp. 16.

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

Warner, B.D. (2010a). Collaborative Asteroid Lightcurve Link (CALL). *http://www.minorplanetobserver.com/astlc/20103Q_ALL.txt*

Warner, B.D. (2010b). *MPO Canopus* v10.1.0.7. Bdw Publishing, Colorado Springs, CO.





THE LIGHTCURVE FOR ASTEROID 836 JOLE

Daniel Coley
Goat Mountain Astronomical Research Station
DanHenge Observatory
1138 Archer Circle, Corona, California, USA, 92882
dan_coley@hotmail.com

(Received: 7 September)

The lightcurve for the main-belt asteroid 836 Jole was determined from observations in 2010 September from the DanHenge Observatory, one of 10 observatories at the Goat Mountain Astronomical Research Station (GMARS, MPC G79). The synodic period was found to be 9.615 ± 0.005 h with an amplitude of 0.35 ± 0.02 mag.

Observations of asteroid 836 Jole were made over three days, 2010 September 4-6, after being selected from the list of asteroid photometry opportunities published on the Collaborative Asteroid Lightcurve Link website (CALL; Warner *et al*., 2010a). All images were taken using a Meade 0.36-m f/10 ACF mounted on a Mathis Instruments MI-500F fork and an SBIG ST-9XE camera working at -15º C. The field of view was 10x10 arcminutes and had an image scale of 1.17 arc-seconds/pixel. Exposures were unbinned, unfiltered, and 90 seconds.

Measurements and analysis were made using *MPO Canopus*, which employs differential aperture photometry to produce the raw data and incorporates the Fourier analysis algorithm (FALC) (Harris *et al.*, 1989) for period analysis. Night-to-night calibration of the zero points was done using 2MASS magnitudes of five comparison stars of similar color to the asteroid. See Warner (2007) and Stephens (2008) for further discussion of this process that provides calibration of nightly zero points typically good to within ± 0.05 mag.

A total of 658 data points was used in the period analysis, which found a synodic period for the lightcurve of 9.615 ± 0.005 h and an amplitude of 0.35 ± 0.02 mag. During the nights observed, the phase angle decreased by 9.9 degrees. The L_{PAB} was 354 deg while the average B_{PAB} was 4 deg. (PAB is the Phase Angle Bisector; see Harris *et al.,* 1984, for the derivation of the PAB). A search of the Asteroid Lightcurve Database (Warner *et al.*, 2010b) found no previously reported results.

References

Harris, A.W., Young, J.W., Scaltriti, F., and Zappalà, V. (1984). "Lightcurves and Phase Relations of the Asteroids 82 Alkmene and 444 Gyptis." *Icarus* **57**, 251-258.

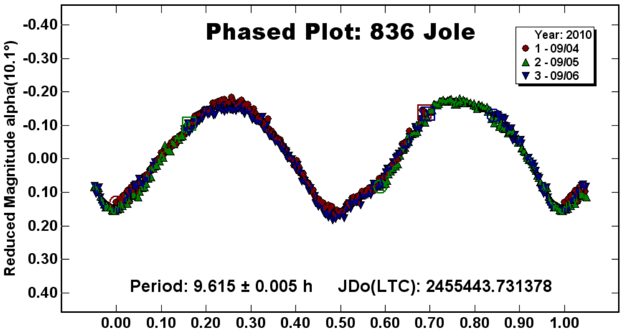
Harris, A.W., Young, J.W., Bowell, E., Martin, L. J., Millis, R. L., Poutanen, M., Scaltriti, F., Zappala, V., Schober, H. J., Debehogne, H, and Zeigler, K. (1989). "Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863." *Icarus* **77**, 171-186.

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

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

Warner, B.D., Harris, A.W., and Pravec, P. (2010a). Lightcurve Targets. *http://www.MinorPlanetObserver.com/astlc/default.htm.*

Warner, B.D., Harris, A.W., and Pravec, P. (2010b). Asteroid Lightcurve Database. Download available at: *http://www.minorplanetobserver.com/astlc/LightcurveParameters.htm.*



POSSIBLE BINARY LIGHTCURVE FOR 3145 WALTER ADAMS

Larry E. Owings
Barnes Ridge Observatory
23220 Barnes Lane
Colfax, CA 95713 USA
lowings@foothill.net

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

Petr Pravec
Astronomical Institute, Academy of Sciences
CZ-25165 Ondrejov, CZECH REPUBLIC

Peter Kusnirak
Astronomical Institute, Academy of Sciences
CZ-25165 Ondrejov, CZECH REPUBLIC

(Received: 13 September)

Lightcurve observations have yielded period determinations for asteroid 3145 Walter Adams. A primary period of 2.7113 ± 0.0001 hr, amplitude of 0.10 ± 0.05, and a possible secondary period of about 17.4 hr. The estimated diameter ratio is D2/D1 = 0.22 ± 0.02.

We report results of photometric observations of asteroid 3145 Walter Adams, for which no previously published lightcurve data has been reported. Photometric data were collected using a 0.43m Planewave CDK17 operating at f/6.80, and Apogee U9 camera, at Barnes Ridge Observatory located in Northern California, USA at an altitude of 762 meters. The camera was binned 2x2 with a resulting image scale of 1.26 arc-seconds per pixel. All images were taken with a camera temperature of –25°C. Images taken on 2010 July 16 were 60 second exposures through a clear filter. Images taken on 2010 July 17 and 18 were 90 second exposures through a clear filter. The remainder of the images were all 210 second exposures through a photometric V filter. All photometric data were obtained with *MaxIm DL* V5 driven by *ACP* V5, analyzed using *MPO Canopus* V10.0 (Warner 2010).

Data were collected from 2010 July 16 through August 19 resulting in 7 data sets totaling 431 data points. The asteroid was tracked through 310.97 revolutions. A primary period of 2.7113 ± 0.0001 hr was determined with a peak-to-peak amplitude of 0.10 ± 0.05 magnitude (Figure 1). A secondary period of about 17.44 hr was determined (Figure 2). Of the two events indicating a possible secondary, one was covered poorly and the other was well covered. The fully covered event is fully consistent with it being a binary system, and suggests a diameter ratio of $D_2/D_1 = 0.22 \pm 0.02$. There are two periods of data that appear to have background stars cross the aperture. Specifically the periods from 2010 July 17 10:16:40 through 10:45:23 UT as seen around phase 0.72 in Figure 2, and from 2010 July 18 08:42:21 through 09:14:29 UT as seen around phase 0.98 in Figure 2. No evidence of background stars was seen in the images taken for either period. Also the periods are longer than would be expected from crossing single stars. There would have to be two or three stars in line to make the anomalous periods. The lightcurves have been re-run with data points for those two periods removed and the same periods for the primary and secondary were found. This is not surprising since there is just not enough high SNR data to begin with. It was decided to not arbitrarily remove the data points for those two periods without having a valid reason.

Acknowledgements

Thanks go to Brian D. Warner at Palmer Divide Observatory and to Petr Pravec and Peter Kusnirak at the Astronomical Institute, Czech Republic, for their support and advice.

References

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

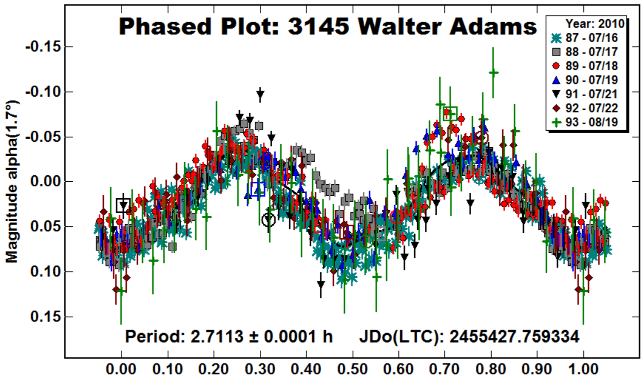


Figure 1. Primary Period with Secondary Period removed.

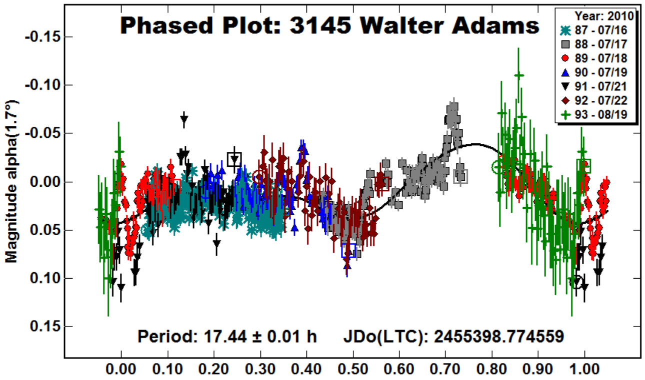


Figure 2. Secondary Period with Primary Period removed.

LIGHTCURVE ANALYSYS OF 996 HILARITAS

Luca Strabla, Ulisse Quadri, Roberto Girelli
Observatory of Bassano Bresciano
via San Michele 4 Bassano Bresciano (BS) Italy
lucapietro.strabla@fastwebnet.it

(Received: 13 September)

The main-belt minor planet 996 Hilaritas was observed in 2010 March and April in order to study its lightcurve. We found a synodic rotation period and amplitude of P = 10.052 ± 0.001 h and A = 0.65 ± 0.03 mag.

The minor planet 996 Hilaritas was observed in 2010 March and April at Bassano Bresciano Observatory using the 0.32-m f/3.1 Schmidt telescope and HX-516 CCD camera. Exposures were 120 sec unguided with a Johnson V filter and binned 2x2. Flat fields and dark frames were taken each night and applied to the raw images. We selected the asteroid from the list in "Lightcurve Photometry Opportunities: 2010 January-March." (Warner *et al.*, 2010) based on the requirement that the target asteroid have an altitude of at least 30° for several hours. We also chose the asteroid because its period of 7.2 h was listed with U = 2, indicating that the period had some uncertainty and so we had hopes of obtaining a higher quality result.

<u>996 Hilaritas</u> The observations covered a span of 34 days, 2010 March 6 - April 9, with 8 individual sessions. *MPO Canopus* (Bdw Publishing, 2010) was used to perform differential photometry on the reduced images with a minimum of three comparison stars on each image. Comparison stars were selected with a colour index of V-R ≈ 0.45 (approximately solar colour) in order to minimize colour errors between the target and comparisons. Because of too low of signal-to-noise ratio, we excluded three sessions. The table below gives the observing circumstances for the remaining five sessions used for period analysis.

#	Date	Phase Angle	Time hours	Num. Obs	Filter
1	2010 March 14	0.1	3.5	73	V
2	2010 March 15	0.5	6.0	121	V
3	2010 March 16	0.9	5.7	134	V
4	2010 April 07	9.9	4.8	100	V
5	2010 April 08	10.3	5.5	118	V

The period analysis was performed using *MPO Canopus,* which uses the FALC algorithm developed by Harris (Harris *et al*., 1989). We obtained an unambiguous bimodal lightcurve result of P = 10.052 ± 0.001 h and A = 0. 65 ± 0.03 mag.

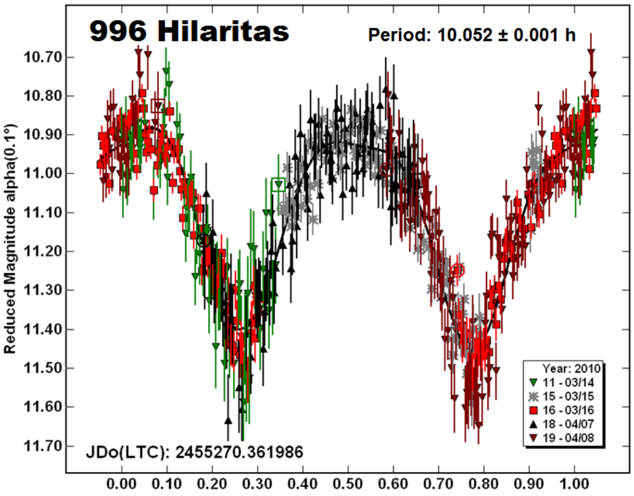
References

Bdw Publishing (2010). MPO Canopus Software, version 10.0.0.6. *http://www.minorplanetobserver.com*

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

Warner, B.D. (2006). *A Practical Guide to Lightcurve Photometry and Analysis*. Bdw Publishing, Colorado Springs, CO.

Warner, B.D., Harris, A.W., Pravec, P., Durech, J., and Benner, L.A.M. (2010). "Lightcurve Photometry Opportunities: 2010 January-March." *Minor Planet Bulletin* **37**, 37-40.



ROTATION PERIOD DETERMINATIONS FOR 266 ALINE AND 850 ALTONA

Frederick Pilcher
4438 Organ Mesa Loop
Las Cruces, NM 88011-8403 USA
pilcher@ic.edu

Vladimir Benishek
Belgrade Astronomical Observatory
Volgina 7, 11060 Belgrade 38, SERBIA

(Received: 15 September)

Synodic rotation periods and amplitudes are found for: 266 Aline 13.011 ± 0.001 hours or 26.023 ± 0.002 hours, 0.07 ± 0.01 mag; 850 Altona 11.197 ± 0.002 hours with a complex lightcurve, 0.12 ± 0.02 mag.

Here we present results of collaborative photometric observations from our two observatories separated by about 120 degrees longitude – enabling the sampling of different parts of asteroid lightcurves within an interval of one to two days. Pilcher at Organ Mesa Observatory used a 0.35 m f/10 Meade LX200 GPS S-C, SBIG STL-1001E CCD, unguided, clear filter, instrumental magnitudes only. Benishek at Belgrade Observatory used a 0.4 m SCT operating at f/10, SBIG ST-10 XME CCD, unfiltered and unguided, instrumental magnitudes only. Photometric measurement, lightcurve analysis, and data sharing were enabled by *MPO Canopus* software. The large number of data points obtained for both objects have been binned in sets of three with time difference not exceeding five minutes to draw the lightcurves.

266 Aline. Denchev et al. (1998) obtained a sparse lightcurve from which they interpreted a 12.3 hour period. New observations on 20 nights 2010 July 18 – Aug. 25 indicate an amplitude of only 0.07 ± 0.01 magnitudes. Lightcurves phased to 13.011 ± 0.001 hours with one maximum and minimum per rotational cycle, or to 26.023 ± 0.002 hours with two unusually symmetric maxima and minima per cycle, provide comparably good fits. A monomodal lightcurve of low amplitude is commonly observed for asteroids at near polar aspect. We consider this interpretation and a 13.011 hour period more likely than a shape highly symmetric over a 180 degree rotation required to produce the bimodal lightcurve. But future observations at a very different aspect will be required to provide a completely secure period determination. Lightcurves phased to both 13.011 hours and 26.023 hours are published here to assist the reader in making an independent evaluation.

850 Altona. Behrend (2010) suggested a period of 4 hours based on a single lightcurve of slightly more than two hours. New observations on 10 nights 2010 June 7 – July 9 show a period of 11.197 ± 0.002 hours, amplitude 0.12 ± 0.02 mag, and an irregular lightcurve.

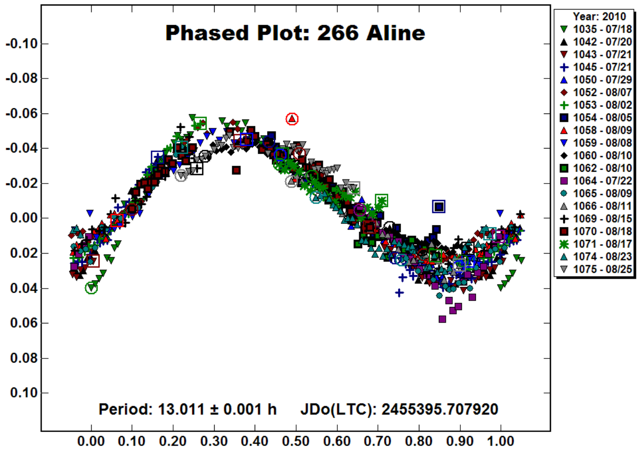
Acknowledgment

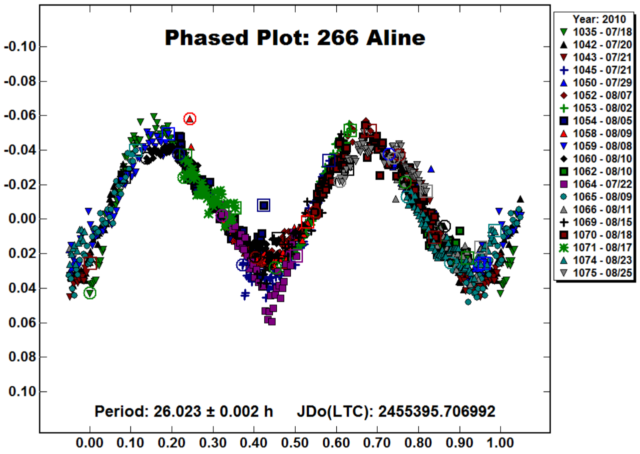
The authors thank Dr. Petr Pravec for help in the data analysis and interpretation for 266 Aline.

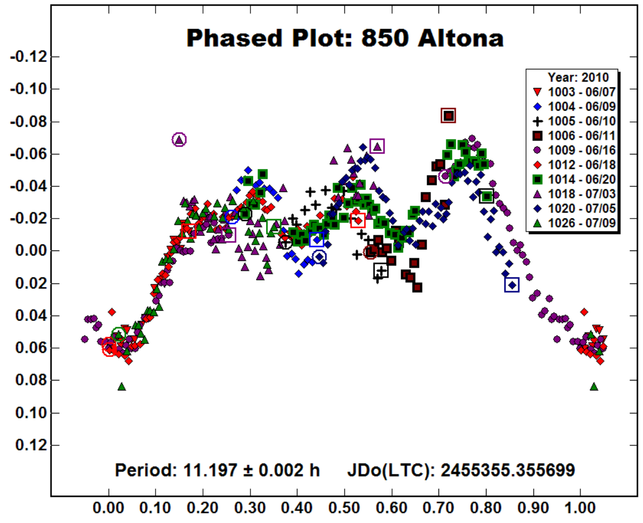
References

Behrend, R., Observatorie de Geneve web site: (2010) http://obswww.unige.ch/~behrend/page_cou.html

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







MINOR PLANETS AT UNUSUALLY FAVORABLE ELONGATIONS IN 2011

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

(Received: 20 September)

A list is presented of minor planets which are much brighter than usual at their 2011 apparitions.

The minor planets in the lists that follow will be much brighter at their 2011 apparitions than at their average distances at maximum elongation. Many years may pass before these minor planets will be again as bright as in 2011. Observers are encouraged to give special attention to those that lie near the limit of their equipment.

These lists have been prepared by an examination of the maximum elongation circumstances of minor planets computed by the author for all years through 2060 with a full perturbation program written by Dr. John Reed, and to whom he expresses his thanks. Elements are from EMP 1992, except that for all minor planets for which new or improved elements have been published subsequently in the Minor Planet Circulars or in electronic form, the newer elements have been used. Planetary positions are from the JPL DE-200 ephemeris, courtesy of Dr. E. Myles Standish.

Any minor planet whose brightest magnitudes near the time of maximum elongation vary by at least 2.0 in this interval and in 2011 will be within 0.3 of the brightest occurring, or vary by at least 3.0 and in 2011 will be within 0.5 of the brightest occurring; and which are visual magnitude 14.5 or brighter, are included. For minor planets brighter than visual magnitude 13.5, which are within the range of a large number of observers, these standards have been relaxed somewhat to include a larger number of objects. Magnitudes have been computed from the updated magnitude parameters published in MPC28104-28116, on 1996 Nov. 25, or more recently in the Minor Planet Circulars.

Oppositions may be in right ascension or in celestial longitude. Here we use still a third representation, maximum elongation from the Sun, instead of opposition. Though unconventional, it has the advantage that many close approaches do not involve actual opposition to the Sun near the time of minimum distance and greatest brightness and are missed by an opposition-based program. Other data are also provided according to the following tabular listings: Minor planet number, date of maximum elongation from the Sun in format yyyy/mm/dd, maximum elongation in degrees, right ascension on date of maximum elongation, declination on date of maximum elongation, both in J2000 coordinates, date of brightest magnitude in format yyyy/mm/dd, brightest magnitude, date of minimum distance in format yyyy/mm/dd, and minimum distance in AU.

Minor planet 1036 Ganymed is the brightest Mars crosser and on 2011 Oct. 29 will be brighter (magnitude 8.3) than at any other time in the interval 1950-2060. Three other numbered minor planets approaching more closely than 0.4 AU will be magnitude 14.5 or brighter in the year 2011, with the dates of brightest magnitude and brightest magnitudes being: 3103 Eger July 31, 13.7; 3288 Seleucus March 23, 14.5; 3554 Amun March 18, 13.7.

Users should note that when the maximum elongation is about 177° or greater, the brightest magnitude is sharply peaked due to enhanced brightening near zero phase angle. Even as near as 10 days before or after minimum magnitude the magnitude is generally about 0.4 greater. This effect takes place in greater time interval for smaller maximum elongations. There is some interest in very small minimum phase angles. For maximum elongations E near 180° at Earth distance Δ, an approximate formula for the minimum phase angle ϕ is ϕ=(180°-E)/(Δ+1).

Table I. Numerical Sequence of Favorable Elongations

Planet	Max Elon D	Max E	RA	Dec	Br Mag D	Br Mag	Min Dist D	Min Dist
10	2011/05/13	175.3°	15h13m	-22°	2011/05/13	9.1	2011/05/14	1.766
15	2011/11/29	164.5°	4h 3m	+36°	2011/11/28	7.9	2011/11/24	1.239
21	2011/07/04	177.9°	18h52m	-25°	2011/07/04	9.4	2011/07/10	1.123
23	2011/01/21	163.9°	8h34m	+35°	2011/01/21	9.1	2011/01/23	1.048
28	2011/01/14	171.7°	7h35m	+13°	2011/01/14	10.0	2011/01/16	1.392
30	2011/11/13	176.1°	3h 7m	+21°	2011/11/13	9.5	2011/11/10	1.084
31	2011/11/02	172.7°	2h23m	+21°	2011/11/03	10.2	2011/11/07	1.639
43	2011/06/27	178.6°	18h24m	-21°	2011/06/27	9.0	2011/06/28	0.819
44	2011/02/10	178.8°	9h36m	+15°	2011/02/10	8.9	2011/02/08	1.106
68	2011/11/11	178.9°	3h 1m	+18°	2011/11/11	9.7	2011/11/04	1.451
90	2011/08/26	176.4°	22h25m	-13°	2011/08/26	11.7	2011/08/24	1.671
109	2011/12/23	164.3°	6h 2m	+39°	2011/12/21	10.8	2011/12/15	0.986
115	2011/11/22	158.1°	3h22m	+41°	2011/11/21	9.6	2011/11/19	0.977
139	2011/03/11	176.1°	11h30m	+ 7°	2011/03/11	10.4	2011/03/12	1.304
192	2011/09/02	178.9°	22h44m	- 9°	2011/09/02	8.4	2011/09/08	0.862
197	2011/07/26	169.6°	20h34m	-29°	2011/07/26	12.0	2011/07/28	1.323
200	2011/11/04	168.5°	2h20m	+26°	2011/11/04	11.3	2011/11/04	1.392
202	2011/02/14	177.8°	9h55m	+14°	2011/02/14	11.0	2011/02/15	1.778
220	2011/08/19	163.5°	21h33m	+ 2°	2011/08/20	12.2	2011/08/21	0.754
281	2011/11/04	178.1°	2h33m	+17°	2011/11/04	13.3	2011/11/03	0.908
312	2011/07/05	164.3°	19h 4m	-38°	2011/07/05	11.9	2011/07/03	1.352
382	2011/06/20	171.6°	17h54m	-31°	2011/06/20	12.3	2011/06/16	1.672
415	2011/11/07	163.9°	3h 7m	+ 0°	2011/11/09	11.3	2011/11/11	1.002
444	2011/08/26	167.4°	21h57m	+ 0°	2011/08/26	10.6	2011/08/27	1.311
449	2011/02/17	174.9°	10h 9m	+16°	2011/02/17	11.6	2011/02/16	1.136
454	2011/05/11	176.5°	15h 9m	-21°	2011/05/11	11.9	2011/05/10	1.341
465	2011/06/20	175.9°	17h55m	-27°	2011/06/20	12.9	2011/06/15	1.547
503	2011/02/08	171.7°	9h37m	+22°	2011/02/07	11.9	2011/02/05	1.305
531	2011/04/17	166.8°	14h10m	+ 0°	2011/04/19	14.5	2011/04/23	1.349
538	2011/08/01	177.8°	20h41m	-15°	2011/08/01	13.0	2011/08/06	1.832
543	2011/09/18	168.4°	23h23m	+ 8°	2011/09/19	13.1	2011/09/21	1.720
545	2011/07/14	167.7°	19h41m	-33°	2011/07/15	12.5	2011/07/15	1.664
548	2011/12/04	175.1°	4h44m	+17°	2011/12/04	12.6	2011/12/03	0.876
569	2011/02/04	179.4°	9h11m	+15°	2011/02/04	12.6	2011/01/30	1.321
575	2011/08/26	171.3°	22h26m	-19°	2011/08/25	13.5	2011/08/24	1.230
593	2011/12/28	168.2°	6h39m	+34°	2011/12/28	11.7	2011/12/29	1.152
622	2011/10/27	162.3°	2h29m	- 3°	2011/10/27	11.8	2011/10/26	0.858
638	2011/05/12	169.1°	15h25m	- 7°	2011/05/12	12.6	2011/05/13	1.290
650	2011/10/28	179.7°	2h 7m	+13°	2011/10/28	14.5	2011/10/27	1.011
668	2011/08/26	168.6°	22h 2m	+ 0°	2011/08/26	14.2	2011/08/25	1.150
678	2011/12/23	178.0°	6h 5m	+25°	2011/12/23	11.1	2011/12/16	1.154
679	2011/07/28	167.8°	20h53m	-29°	2011/07/31	11.4	2011/08/09	1.102
688	2011/09/16	179.3°	23h36m	- 3°	2011/09/16	13.3	2011/09/12	1.400
696	2011/11/21	160.6°	3h21m	+38°	2011/11/20	12.2	2011/11/18	1.428
704	2011/07/18	172.9°	19h44m	-14°	2011/07/18	10.0	2011/07/23	1.900

Planet	Max Elon D	Max E	RA	Dec	Br Mag D	Br Mag	Min Dist D	Min Dist
718	2011/05/14	177.0°	15h18m	-21°	2011/05/14	12.7	2011/05/12	1.454
724	2011/10/21	178.6°	1h43m	+ 9°	2011/10/21	14.4	2011/10/24	0.873
735	2011/10/26	173.3°	2h 7m	+ 5°	2011/10/25	11.2	2011/10/16	0.949
747	2011/01/15	171.2°	7h37m	+12°	2011/01/14	10.6	2011/01/03	1.356
819	2011/05/19	169.9°	15h34m	-29°	2011/05/20	13.6	2011/05/25	0.938
834	2011/07/01	173.4°	18h35m	-16°	2011/07/01	12.5	2011/06/30	1.496
852	2011/09/25	154.2°	0h20m	-24°	2011/09/20	11.7	2011/09/13	0.870
854	2011/05/22	170.5°	16h 4m	-11°	2011/05/23	14.0	2011/05/28	0.997
865	2011/02/26	170.7°	10h17m	+ 0°	2011/02/25	13.9	2011/02/22	1.031
880	2011/10/17	154.8°	0h34m	+31°	2011/10/14	14.0	2011/10/11	1.102
896	2011/05/29	177.8°	16h19m	-23°	2011/05/29	13.2	2011/05/31	0.901
915	2011/11/30	170.3°	4h20m	+31°	2011/11/30	13.4	2011/11/27	0.950
918	2011/08/09	174.6°	21h19m	-21°	2011/08/09	13.5	2011/08/12	1.373
945	2011/02/09	177.0°	9h30m	+11°	2011/02/09	12.5	2011/02/08	1.241
948	2011/03/14	179.0°	11h36m	+ 3°	2011/03/14	14.4	2011/03/14	1.554
965	2011/10/31	177.3°	2h23m	+11°	2011/10/31	12.7	2011/11/07	1.459
970	2011/09/27	171.9°	0h 1m	+ 9°	2011/09/28	14.2	2011/10/04	0.966
984	2011/08/02	178.7°	20h49m	-19°	2011/08/02	11.9	2011/08/08	1.439
986	2011/10/06	156.2°	1h23m	-17°	2011/10/05	13.0	2011/10/03	1.570
987	2011/09/12	173.2°	23h11m	+ 2°	2011/09/12	12.3	2011/09/09	1.425
1036	2011/10/29	178.4°	2h 6m	+13°	2011/10/28	8.3	2011/10/13	0.359
1044	2011/05/16	179.3°	15h30m	-18°	2011/05/16	13.4	2011/05/21	1.304
1047	2011/08/31	168.1°	22h56m	-19°	2011/09/01	13.4	2011/09/06	0.880
1059	2011/08/17	164.5°	21h24m	+ 1°	2011/08/16	13.4	2011/08/12	1.224
1064	2011/06/16	174.9°	17h33m	-28°	2011/06/16	12.7	2011/06/21	1.146
1072	2011/10/23	178.2°	1h54m	+ 9°	2011/10/24	13.4	2011/10/27	1.477
1077	2011/09/21	177.5°	23h51m	+ 1°	2011/09/21	13.6	2011/09/20	0.914
1123	2011/10/16	168.5°	1h38m	- 2°	2011/10/16	13.3	2011/10/17	0.897
1127	2011/09/19	158.5°	0h30m	-20°	2011/09/23	13.4	2011/09/28	1.096
1136	2011/10/21	179.0°	1h38m	+11°	2011/10/21	12.5	2011/10/14	0.957
1151	2011/08/24	165.2°	21h50m	+ 2°	2011/08/26	13.9	2011/08/28	0.758
1166	2011/06/29	172.8°	18h23m	-16°	2011/06/29	12.9	2011/07/02	1.021
1188	2011/10/01	179.3°	0h29m	+ 3°	2011/10/01	12.6	2011/10/01	0.795
1192	2011/03/02	157.5°	11h 1m	+29°	2011/02/28	14.5	2011/02/26	0.829
1224	2011/10/08	164.7°	0h25m	+19°	2011/10/08	13.0	2011/10/09	0.871
1227	2011/08/09	160.6°	21h36m	-34°	2011/08/08	13.8	2011/08/07	1.646
1263	2011/02/03	154.8°	8h21m	- 6°	2011/02/01	13.6	2011/01/30	1.325
1283	2011/08/31	179.8°	22h36m	- 8°	2011/08/31	13.6	2011/09/06	1.681
1284	2011/11/22	162.3°	3h25m	+36°	2011/11/21	13.0	2011/11/21	1.230
1318	2011/03/13	172.7°	11h34m	+10°	2011/03/13	13.3	2011/03/17	0.871
1325	2011/08/27	169.6°	22h35m	-20°	2011/08/28	13.1	2011/08/30	0.909
1335	2011/08/21	177.8°	21h56m	-10°	2011/08/21	14.4	2011/08/25	0.953
1362	2011/07/29	176.5°	20h37m	-22°	2011/07/29	14.4	2011/08/11	1.522
1401	2011/07/08	177.9°	19h 6m	-20°	2011/07/08	13.9	2011/07/16	0.968
1438	2011/11/14	179.3°	3h18m	+18°	2011/11/14	14.4	2011/11/08	1.548
1448	2011/01/08	169.5°	7h24m	+32°	2011/01/08	14.4	2011/01/10	0.968
1479	2011/11/25	170.7°	3h57m	+29°	2011/11/26	14.0	2011/11/29	1.242
1501	2011/09/14	173.6°	23h36m	- 9°	2011/09/15	14.0	2011/09/20	1.013
1534	2011/01/10	166.0°	7h40m	+35°	2011/01/10	13.9	2011/01/09	1.079
1535	2011/07/18	175.0°	19h44m	-16°	2011/07/18	13.9	2011/07/18	1.555
1536	2011/10/10	179.8°	1h 2m	+ 6°	2011/10/10	14.4	2011/10/07	0.778
1568	2011/09/04	160.4°	23h47m	-21°	2011/09/06	13.6	2011/09/09	0.813
1573	2011/10/18	177.4°	1h37m	+ 7°	2011/10/18	13.4	2011/10/15	0.828
1592	2011/07/20	174.4°	20h 4m	-26°	2011/07/19	13.2	2011/07/16	0.933
1607	2011/08/21	171.4°	22h18m	-19°	2011/08/23	12.9	2011/08/29	0.816
1666	2011/10/01	174.2°	0h18m	+ 8°	2011/10/01	13.8	2011/09/26	0.803
1688	2011/06/29	167.0°	18h36m	-10°	2011/06/30	14.5	2011/07/01	0.993
1759	2011/09/08	178.9°	23h 7m	- 6°	2011/09/08	14.2	2011/09/12	0.829
1763	2011/07/21	178.9°	20h 3m	-21°	2011/07/21	13.5	2011/07/28	0.778
1768	2011/09/23	178.6°	0h 1m	- 1°	2011/09/23	14.5	2011/09/26	1.053
1807	2011/10/22	176.4°	1h40m	+14°	2011/10/22	13.3	2011/10/19	0.839
1820	2011/09/15	174.9°	23h39m	- 7°	2011/09/14	14.1	2011/09/06	0.791
2017	2011/08/02	172.8°	20h39m	-10°	2011/08/02	14.0	2011/08/01	0.824
2118	2011/10/14	171.1°	1h 2m	+16°	2011/10/15	14.3	2011/10/20	1.137
2156	2011/09/27	177.0°	0h15m	- 1°	2011/09/27	13.7	2011/09/29	0.803
2167	2011/02/12	169.3°	9h27m	+ 3°	2011/02/12	14.4	2011/02/16	1.123
2183	2011/08/09	149.9°	22h26m	-41°	2011/08/10	13.6	2011/08/11	0.947
2237	2011/10/07	176.1°	0h55m	+ 1°	2011/10/07	14.3	2011/10/07	1.470
2423	2011/10/19	171.2°	1h20m	+17°	2011/10/17	13.8	2011/10/06	0.646
2651	2011/09/19	154.0°	0h41m	-23°	2011/09/24	13.9	2011/09/29	1.187
2731	2011/08/01	171.5°	20h34m	- 9°	2011/08/01	14.1	2011/07/29	1.603
2751	2011/12/24	178.7°	6h 7m	+22°	2011/12/24	14.3	2011/12/23	1.007
2757	2011/12/05	178.9°	4h46m	+23°	2011/12/05	14.4	2011/12/03	1.554
2844	2011/07/01	176.8°	18h38m	-19°	2011/07/01	14.5	2011/07/01	0.828
2870	2011/10/17	172.3°	1h40m	+ 2°	2011/10/17	14.4	2011/10/13	0.909
2892	2011/01/12	164.0°	7h38m	+37°	2011/01/10	14.0	2011/01/06	1.726
3080	2011/10/30	174.5°	2h21m	+ 8°	2011/10/29	14.0	2011/10/24	1.187
3103	2011/07/14	122.8°	22h51m	+ 8°	2011/07/31	13.7	2011/08/04	0.153
3116	2011/08/10	169.7°	21h37m	-25°	2011/08/11	13.9	2011/08/16	0.822
3156	2011/04/01	177.9°	12h39m	- 6°	2011/04/01	14.4	2011/03/27	1.535
3165	2011/10/01	171.9°	0h40m	- 4°	2011/09/30	14.4	2011/09/24	0.906
3229	2011/07/23	177.8°	20h12m	-22°	2011/07/23	14.4	2011/07/26	0.970
3288	2011/02/07	118.4°	12h44m	-21°	2011/03/23	14.5	2011/03/30	0.270
3554	2011/03/18	175.4°	11h46m	+ 5°	2011/03/18	13.7	2011/03/18	0.252
3628	2011/09/11	176.9°	23h20m	- 7°	2011/09/10	13.5	2011/09/08	0.775
3990	2011/10/24	175.6°	2h 1m	+ 7°	2011/10/24	14.5	2011/10/23	2.009
4090	2011/06/13	179.8°	17h24m	-23°	2011/06/13	14.5	2011/06/15	0.854
4284	2011/07/22	170.5°	19h50m	-11°	2011/07/22	13.5	2011/07/24	0.741
4603	2011/07/29	166.2°	20h40m	-32°	2011/07/27	14.2	2011/07/22	1.074
4615	2011/09/23	179.1°	0h 2m	- 0°	2011/09/23	14.4	2011/09/20	1.179
5052	2011/09/12	175.2°	23h13m	+ 0°	2011/09/12	14.5	2011/09/13	0.816
5064	2011/08/11	175.5°	21h16m	-11°	2011/08/11	14.3	2011/08/04	0.902
5143	2011/11/09	149.4°	3h 6m	+47°	2011/12/01	13.0	2011/12/11	0.205
5168	2011/02/26	178.1°	10h36m	+10°	2011/02/26	14.3	2011/03/02	0.891
5231	2011/12/25	179.0°	6h15m	+24°	2011/12/25	14.3	2011/12/21	1.317
5352	2011/12/10	179.8°	5h 8m	+22°	2011/12/10	14.4	2011/12/08	1.027
5438	2011/01/14	175.4°	7h43m	+25°	2011/01/15	13.7	2011/01/23	1.270
5682	2011/10/25	179.5°	1h56m	+12°	2011/10/25	14.5	2011/10/13	0.691
6192	2011/07/30	177.8°	20h41m	-20°	2011/07/30	13.2	2011/07/25	0.684
6306	2011/12/12	177.7°	5h15m	+20°	2011/12/12	14.1	2011/12/11	1.068
6649	2011/08/09	177.5°	21h17m	-18°	2011/08/09	14.2	2011/08/08	0.881
6823	2011/12/07	173.4°	4h53m	+15°	2011/12/07	14.5	2011/12/05	1.236
6905	2011/10/06	164.7°	1h 5m	- 9°	2011/10/05	13.8	2011/10/03	1.136
7750	2011/09/07	145.3°	21h56m	+24°	2011/08/29	14.4	2011/08/25	0.841
8345	2011/12/29	179.3°	6h28m	+23°	2011/12/29	14.2	2011/12/24	0.851
10142	2011/09/30	159.6°	0h56m	-16°	2011/10/02	14.5	2011/10/04	1.102
13441	2011/08/25	163.8°	21h45m	+ 3°	2011/08/26	14.5	2011/08/29	0.972
15633	2011/06/18	168.1°	17h34m	-11°	2011/06/16	14.5	2011/06/11	0.944
16182	2011/08/23	175.1°	22h17m	-15°	2011/08/23	14.5	2011/08/27	0.774
16666	2011/11/24	178.4°	4h 2m	+19°	2011/11/24	13.9	2011/11/28	0.841
20932	2011/10/08	176.0°	0h57m	+ 1°	2011/10/08	14.5	2011/10/03	0.875
23143	2011/08/01	169.8°	20h31m	- 8°	2011/08/02	14.5	2011/08/06	0.898
23200	2011/10/25	179.6°	1h56m	+11°	2011/10/25	13.6	2011/10/23	0.821
99915	2011/01/22	151.8°	8h44m	- 7°	2011/01/16	13.8	2011/01/11	0.483

Table II. Temporal Sequence of Favorable Elongations

Planet	Max Elon D	Max E	RA	Dec	Br Mag D	Br Mag	Min Dist D	Min Dist
1448	2011/01/08	169.5°	7h24m	+32°	2011/01/08	14.4	2011/01/10	0.968
1534	2011/01/10	166.0°	7h40m	+35°	2011/01/10	13.9	2011/01/09	1.079
2892	2011/01/12	164.0°	7h38m	+37°	2011/01/10	14.0	2011/01/06	1.726
28	2011/01/14	171.7°	7h35m	+13°	2011/01/14	10.0	2011/01/16	1.392
5438	2011/01/14	175.4°	7h43m	+25°	2011/01/15	13.7	2011/01/23	1.270
99915	2011/01/22	151.8°	8h44m	- 7°	2011/01/16	13.8	2011/01/11	0.483
747	2011/01/15	171.2°	7h37m	+12°	2011/01/14	10.6	2011/01/03	1.356
23	2011/01/21	163.9°	8h34m	+35°	2011/01/21	9.1	2011/01/23	1.048
1263	2011/02/03	154.8°	8h21m	- 6°	2011/02/01	13.6	2011/01/30	1.325
569	2011/02/04	179.4°	9h11m	+15°	2011/02/04	12.6	2011/01/30	1.321
3288	2011/02/07	118.4°	12h44m	-21°	2011/03/23	14.5	2011/03/30	0.270
503	2011/02/08	171.7°	9h37m	+22°	2011/02/07	11.9	2011/02/05	1.305
945	2011/02/09	177.0°	9h30m	+11°	2011/02/09	12.5	2011/02/08	1.241
44	2011/02/10	178.8°	9h36m	+15°	2011/02/10	8.9	2011/02/08	1.106
2167	2011/02/12	169.3°	9h27m	+ 3°	2011/02/12	14.4	2011/02/16	1.123
202	2011/02/14	177.8°	9h55m	+14°	2011/02/14	11.0	2011/02/15	1.778
449	2011/02/17	174.9°	10h 9m	+16°	2011/02/17	11.6	2011/02/16	1.136
865	2011/02/26	170.7°	10h17m	+ 0°	2011/02/25	13.9	2011/02/22	1.031
5168	2011/02/26	178.1°	10h36m	+10°	2011/02/26	14.3	2011/03/02	0.891
1192	2011/03/02	157.5°	11h 1m	+29°	2011/02/28	14.5	2011/02/26	0.829
139	2011/03/11	176.1°	11h30m	+ 7°	2011/03/11	10.4	2011/03/12	1.304
1318	2011/03/13	172.7°	11h34m	+10°	2011/03/13	13.3	2011/03/17	0.871
948	2011/03/14	179.0°	11h36m	+ 3°	2011/03/14	14.4	2011/03/14	1.554
3554	2011/03/18	175.4°	11h46m	+ 5°	2011/03/18	13.7	2011/03/18	0.252
3156	2011/04/01	177.9°	12h39m	- 6°	2011/04/01	14.4	2011/03/27	1.535
531	2011/04/17	166.8°	14h10m	+ 0°	2011/04/19	14.5	2011/04/23	1.349
454	2011/05/11	176.5°	15h 9m	-21°	2011/05/11	11.9	2011/05/10	1.341
638	2011/05/12	169.1°	15h25m	- 7°	2011/05/12	12.6	2011/05/13	1.290
10	2011/05/13	175.3°	15h13m	-22°	2011/05/13	9.1	2011/05/14	1.766
718	2011/05/14	177.0°	15h18m	-21°	2011/05/14	12.7	2011/05/12	1.454
1044	2011/05/16	179.3°	15h30m	-18°	2011/05/16	13.4	2011/05/21	1.304
819	2011/05/19	169.9°	15h34m	-29°	2011/05/20	13.6	2011/05/25	0.938
854	2011/05/22	170.5°	16h 4m	-11°	2011/05/23	14.0	2011/05/28	0.997
896	2011/05/29	177.8°	16h19m	-23°	2011/05/29	13.2	2011/05/31	0.901
4090	2011/06/13	179.8°	17h24m	-23°	2011/06/13	14.5	2011/06/15	0.854
1064	2011/06/16	174.9°	17h33m	-28°	2011/06/16	12.7	2011/06/21	1.146
15633	2011/06/18	168.1°	17h34m	-11°	2011/06/16	14.5	2011/06/11	0.944
382	2011/06/20	171.6°	17h54m	-31°	2011/06/20	12.3	2011/06/16	1.672
465	2011/06/20	175.9°	17h55m	-27°	2011/06/20	12.9	2011/06/15	1.547
43	2011/06/27	178.6°	18h24m	-21°	2011/06/27	9.0	2011/06/28	0.819
1166	2011/06/29	172.8°	18h23m	-16°	2011/06/29	12.9	2011/07/02	1.021
1688	2011/06/29	167.0°	18h36m	-10°	2011/06/30	14.5	2011/07/01	0.993
834	2011/07/01	173.4°	18h35m	-16°	2011/07/01	12.5	2011/06/30	1.496
2844	2011/07/01	176.8°	18h38m	-19°	2011/07/01	14.5	2011/07/01	0.828
21	2011/07/04	177.9°	18h52m	-25°	2011/07/04	9.4	2011/07/10	1.123
312	2011/07/05	164.3°	19h 4m	-38°	2011/07/05	11.9	2011/07/03	1.352
1401	2011/07/08	177.9°	19h 6m	-20°	2011/07/08	13.9	2011/07/16	0.968
545	2011/07/14	167.7°	19h41m	-33°	2011/07/15	12.5	2011/07/15	1.664
3103	2011/07/14	122.8°	22h51m	+ 8°	2011/07/31	13.7	2011/08/04	0.153
704	2011/07/18	172.9°	19h44m	-14°	2011/07/18	10.0	2011/07/23	1.900
1535	2011/07/18	175.0°	19h44m	-16°	2011/07/18	13.9	2011/07/18	1.555
1592	2011/07/20	174.4°	20h 4m	-26°	2011/07/19	13.2	2011/07/16	0.933
1763	2011/07/21	178.9°	20h 3m	-21°	2011/07/21	13.5	2011/07/28	0.778
4284	2011/07/22	170.5°	19h50m	-11°	2011/07/22	13.5	2011/07/24	0.741
3229	2011/07/23	177.8°	20h12m	-22°	2011/07/23	14.4	2011/07/26	0.970
197	2011/07/26	169.6°	20h34m	-29°	2011/07/26	12.0	2011/07/28	1.323
679	2011/07/28	167.8°	20h53m	-29°	2011/07/31	11.4	2011/08/09	1.102
1362	2011/07/29	176.5°	20h37m	-22°	2011/07/29	14.4	2011/08/11	1.522
4603	2011/07/29	166.2°	20h40m	-32°	2011/07/27	14.2	2011/07/22	1.074
6192	2011/07/30	177.8°	20h41m	-20°	2011/07/30	13.2	2011/07/25	0.684
538	2011/08/01	177.8°	20h41m	-15°	2011/08/01	13.0	2011/08/06	1.832
2731	2011/08/01	171.5°	20h34m	- 9°	2011/08/01	14.1	2011/07/29	1.603
23143	2011/08/01	169.8°	20h31m	- 8°	2011/08/02	14.5	2011/08/06	0.898
984	2011/08/02	178.7°	20h49m	-19°	2011/08/02	11.9	2011/08/08	1.439
2017	2011/08/02	172.8°	20h39m	-10°	2011/08/02	14.0	2011/08/01	0.824
918	2011/08/09	174.6°	21h19m	-21°	2011/08/09	13.5	2011/08/12	1.373
1227	2011/08/09	160.6°	21h36m	-34°	2011/08/08	13.8	2011/08/07	1.646
2183	2011/08/09	149.9°	22h26m	-41°	2011/08/10	13.6	2011/08/11	0.947
6649	2011/08/09	177.5°	21h17m	-18°	2011/08/09	14.2	2011/08/08	0.881
3116	2011/08/10	169.7°	21h37m	-25°	2011/08/11	13.9	2011/08/16	0.822

Planet	Max Elon D	Max E	RA	Dec	Br Mag D	Br Mag	Min Dist D	Min Dist
5064	2011/08/11	175.5°	21h16m	-11°	2011/08/11	14.3	2011/08/04	0.902
1059	2011/08/17	164.5°	21h24m	+ 1°	2011/08/16	13.4	2011/08/12	1.224
220	2011/08/19	163.5°	21h33m	+ 2°	2011/08/20	12.2	2011/08/21	0.754
1335	2011/08/21	177.8°	21h56m	-10°	2011/08/21	14.4	2011/08/25	0.953
1607	2011/08/21	171.4°	22h18m	-19°	2011/08/23	12.9	2011/08/29	0.816
16182	2011/08/23	175.1°	22h17m	-15°	2011/08/23	14.5	2011/08/27	0.774
1151	2011/08/24	165.2°	21h50m	+ 2°	2011/08/26	13.9	2011/08/28	0.758
13441	2011/08/25	163.8°	21h45m	+ 3°	2011/08/26	14.5	2011/08/29	0.972
90	2011/08/26	176.4°	22h25m	-13°	2011/08/26	11.7	2011/08/24	1.671
444	2011/08/26	167.4°	21h57m	+ 0°	2011/08/26	10.6	2011/08/27	1.311
575	2011/08/26	171.3°	22h26m	-19°	2011/08/25	13.5	2011/08/24	1.230
668	2011/08/26	168.6°	22h 2m	+ 0°	2011/08/26	14.2	2011/08/25	1.150
1325	2011/08/27	169.6°	22h35m	-20°	2011/08/28	13.1	2011/08/30	0.909
1047	2011/08/31	168.1°	22h56m	-19°	2011/09/01	13.4	2011/09/06	0.880
1283	2011/08/31	179.8°	22h36m	- 8°	2011/08/31	13.6	2011/09/06	1.681
192	2011/09/02	178.9°	22h44m	- 9°	2011/09/02	8.4	2011/09/08	0.862
1568	2011/09/04	160.4°	23h47m	-21°	2011/09/06	13.6	2011/09/09	0.813
7750	2011/09/07	145.3°	21h56m	+24°	2011/08/29	14.4	2011/08/25	0.841
1759	2011/09/08	178.9°	23h 7m	- 6°	2011/09/08	14.2	2011/09/12	0.829
3628	2011/09/11	176.9°	23h20m	- 7°	2011/09/10	13.5	2011/09/08	0.775
987	2011/09/12	173.2°	23h11m	+ 2°	2011/09/12	12.3	2011/09/09	1.425
5052	2011/09/12	175.2°	23h13m	+ 0°	2011/09/12	14.5	2011/09/13	0.816
1501	2011/09/14	173.6°	23h36m	- 9°	2011/09/15	14.0	2011/09/20	1.013
1820	2011/09/15	174.9°	23h39m	- 7°	2011/09/14	14.1	2011/09/06	0.791
688	2011/09/16	179.3°	23h36m	- 3°	2011/09/16	13.3	2011/09/12	1.400
543	2011/09/18	168.4°	23h23m	+ 8°	2011/09/19	13.1	2011/09/21	1.720
1127	2011/09/19	158.5°	0h30m	-20°	2011/09/23	13.4	2011/09/28	1.096
2651	2011/09/19	154.0°	0h41m	-23°	2011/09/24	13.9	2011/09/29	1.187
1077	2011/09/21	177.5°	23h51m	+ 1°	2011/09/21	13.6	2011/09/20	0.914
1768	2011/09/23	178.6°	0h 1m	- 1°	2011/09/23	14.5	2011/09/26	1.053
4615	2011/09/23	179.1°	0h 2m	- 0°	2011/09/23	14.4	2011/09/20	1.179
852	2011/09/25	154.2°	0h20m	-24°	2011/09/20	11.7	2011/09/13	0.870
970	2011/09/27	171.9°	0h 1m	+ 9°	2011/09/28	14.2	2011/10/04	0.966
2156	2011/09/27	177.0°	0h15m	- 1°	2011/09/27	13.7	2011/09/29	0.803
10142	2011/09/30	159.6°	0h56m	-16°	2011/10/02	14.5	2011/10/04	1.102
1188	2011/10/01	179.3°	0h29m	+ 3°	2011/10/01	12.6	2011/10/01	0.795
1666	2011/10/01	174.2°	0h18m	+ 8°	2011/10/01	13.8	2011/09/26	0.803
3165	2011/10/01	171.9°	0h40m	- 4°	2011/09/30	14.4	2011/09/24	0.906
986	2011/10/06	156.2°	1h23m	-17°	2011/10/05	13.0	2011/10/03	1.570
6905	2011/10/06	164.7°	1h 5m	- 9°	2011/10/05	13.8	2011/10/03	1.136
2237	2011/10/07	176.1°	0h55m	+ 1°	2011/10/07	14.3	2011/10/07	1.470
1224	2011/10/08	164.7°	0h25m	+19°	2011/10/08	13.0	2011/10/09	0.871
20932	2011/10/08	176.0°	0h57m	+ 1°	2011/10/08	14.5	2011/10/03	0.875
1536	2011/10/10	179.8°	1h 2m	+ 6°	2011/10/10	14.4	2011/10/07	0.778
2118	2011/10/14	171.1°	1h 2m	+16°	2011/10/15	14.3	2011/10/20	1.137
1123	2011/10/16	168.5°	1h38m	- 2°	2011/10/16	13.3	2011/10/17	0.897
880	2011/10/17	154.8°	0h34m	+31°	2011/10/14	14.0	2011/10/11	1.102
2870	2011/10/17	172.3°	1h40m	+ 2°	2011/10/17	14.4	2011/10/13	0.909
1573	2011/10/18	177.4°	1h37m	+ 7°	2011/10/18	13.4	2011/10/15	0.828
2423	2011/10/19	171.2°	1h20m	+17°	2011/10/17	13.8	2011/10/06	0.646
724	2011/10/21	178.6°	1h43m	+ 9°	2011/10/21	14.4	2011/10/24	0.873
1136	2011/10/21	179.0°	1h38m	+11°	2011/10/21	12.5	2011/10/14	0.957
1807	2011/10/22	176.4°	1h40m	+14°	2011/10/22	13.3	2011/10/19	0.839
1072	2011/10/23	178.2°	1h54m	+ 9°	2011/10/24	13.4	2011/10/27	1.477
3990	2011/10/24	175.6°	2h 1m	+ 7°	2011/10/24	14.5	2011/10/23	2.009
5682	2011/10/25	179.5°	1h56m	+12°	2011/10/25	14.5	2011/10/13	0.691
23200	2011/10/25	179.6°	1h56m	+11°	2011/10/25	13.6	2011/10/23	0.821
735	2011/10/26	173.3°	2h 7m	+ 5°	2011/10/25	11.2	2011/10/16	0.949
622	2011/10/27	162.3°	2h29m	- 3°	2011/10/27	11.8	2011/10/26	0.858
650	2011/10/28	179.7°	2h 7m	+13°	2011/10/28	14.5	2011/10/27	1.011
1036	2011/10/29	178.4°	2h 6m	+13°	2011/10/28	8.3	2011/10/13	0.359
3080	2011/10/30	174.5°	2h21m	+ 8°	2011/10/29	14.0	2011/10/24	1.187
965	2011/10/31	177.3°	2h23m	+11°	2011/10/31	12.7	2011/11/07	1.459
31	2011/11/02	172.7°	2h23m	+21°	2011/11/03	10.2	2011/11/07	1.639
200	2011/11/04	168.5°	2h20m	+26°	2011/11/04	11.3	2011/11/04	1.392
281	2011/11/04	178.1°	2h33m	+17°	2011/11/04	13.3	2011/11/03	0.908
415	2011/11/07	163.9°	3h 7m	+ 0°	2011/11/09	11.3	2011/11/11	1.002
5143	2011/11/09	149.4°	3h 6m	+47°	2011/12/01	13.0	2011/12/11	0.205
68	2011/11/11	178.9°	3h 1m	+18°	2011/11/11	9.7	2011/11/04	1.451
30	2011/11/13	176.1°	3h 7m	+21°	2011/11/13	9.5	2011/11/10	1.084
1438	2011/11/14	179.3°	3h18m	+18°	2011/11/14	14.4	2011/11/08	1.548
696	2011/11/21	160.6°	3h21m	+38°	2011/11/20	12.2	2011/11/18	1.428
115	2011/11/22	158.1°	3h22m	+41°	2011/11/21	9.6	2011/11/19	0.977
1284	2011/11/22	162.3°	3h25m	+36°	2011/11/21	13.0	2011/11/21	1.230
16666	2011/11/24	178.4°	4h 2m	+19°	2011/11/24	13.9	2011/11/28	0.841
1479	2011/11/25	170.7°	3h57m	+29°	2011/11/26	14.0	2011/11/29	1.242
15	2011/11/29	164.5°	4h 3m	+36°	2011/11/28	7.9	2011/11/24	1.239
915	2011/11/30	170.3°	4h20m	+31°	2011/11/30	13.4	2011/11/27	0.950
548	2011/12/04	175.1°	4h44m	+17°	2011/12/04	12.6	2011/12/03	0.876
2757	2011/12/05	178.9°	4h46m	+23°	2011/12/05	14.4	2011/12/03	1.554
6823	2011/12/07	173.4°	4h53m	+15°	2011/12/07	14.5	2011/12/05	1.236
5352	2011/12/10	179.8°	5h 8m	+22°	2011/12/10	14.4	2011/12/08	1.027
6306	2011/12/12	177.7°	5h15m	+20°	2011/12/12	14.1	2011/12/11	1.068
109	2011/12/23	164.3°	6h 2m	+39°	2011/12/21	10.8	2011/12/15	0.986
678	2011/12/23	178.0°	6h 5m	+25°	2011/12/23	11.1	2011/12/16	1.154
2751	2011/12/24	178.7°	6h 7m	+22°	2011/12/24	14.3	2011/12/23	1.007
5231	2011/12/25	179.0°	6h15m	+24°	2011/12/25	14.3	2011/12/21	1.317
593	2011/12/28	168.2°	6h39m	+34°	2011/12/28	11.7	2011/12/29	1.152
8345	2011/12/29	179.3°	6h28m	+23°	2011/12/29	14.2	2011/12/24	0.851

LIGHTCURVES AND SPIN PERIODS FROM THE WISE OBSERVATORY – 2010

David Polishook
The Wise Observatory and
the Department of Geophysics and Planetary Sciences
Tel-Aviv University, Tel-Aviv 69978, Israel
david@wise.tau.ac.il

(Received: 23 September)

We report lightcurve and period analysis results for ten asteroids serendipitously traveling through the field of view of Wise Observatory's telescopes while observing other targets.

Photometry of asteroids has been done at the Wise Observatory since 2004. We have observed near-Earth asteroids (Polishook and Brosch, 2008), binary asteroids (Polishook et al., 2009; Polishook et al., 2010), pairs of asteroids (Pravec et al. 2010) and small main-belt asteroids (Polishook and Brosch, 2009). While focusing on a specific target, some random asteroids cross our field of view. These objects are measured along with the prime targets, a lightcurve is drawn, and the spin period determined if possible. This paper presents photometric results of 10 asteroids with mostly secure periods. These and other measurements of other asteroids with short coverage of the spin or with low S/N can be obtained from the author by request.

Observations were performed using the two telescopes of the Wise Observatory (MPC 097): a 1-m Ritchey-Chrétien telescope and a 0.46-m Centurion telescope (referred to as *C18;* see Brosch et al., 2008, for a description of the telescope and its performance). The 1-m telescope is equipped with a cryogenically-cooled Princeton Instruments (PI) CCD. At the f/7 focus of the telescope this CCD covers a field of view of 13'x13' with 1340x1300 pixels (0.58" per pixel, unbinned). The *C18* telescope was used with an SBIG STL-6303E CCD at the f/2.8 prime focus. This CCD covers a wide field of view of 75'x50' with 3072x2048 pixels, with each pixel subtending 1.47 arcsec, unbinned. Observations were performed in "white light" with no filters (Clear). Exposure times were 120–300s, all with auto-guider. The asteroids were observed while crossing a single field per night, thus the same comparison stars were used while calibrating the images.

The observational circumstances are summarized in Table I, which lists the asteroid's designation, the telescope and CCD, the filter, the observation date, the time span of the observation during that night, the number of images obtained, the object's heliocentric distance (r), geocentric distance (Δ), phase angle (α), and the Phase Angle Bisector (PAB) ecliptic coordinates (L_{PAB}, B_{PAB} - see Harris et al. (1984) for the definition and ways of calculating these parameters).

The images were reduced in a standard way. We used the IRAF *phot* function for the photometric measurements. After measuring, the photometric values were calibrated to a differential magnitude level using ~550 local comparison stars per field of the *C18* (~70 stars at the field of the 1-m). The brightness of these stars remained constant to ± 0.02 mag. Astrometric solutions were obtained using *PinPoint* (*www.dc3.com*) and the asteroids were identified in the MPC web database. Analysis for the lightcurve period and amplitude was done by Fourier series analysis (Harris and Lupishko 1989). See Polishook and Brosch (2009) for complete

Asteroid	Scope	CCD	Filter	Date	Time span [hours]	N	r [AU]	Δ [AU]	α [Deg]	L_{PAB} [Deg]	B_{PAB} [Deg]
8523 Bouillabaisse	C18	STL	Clear	Aug 17, 2010	4.67	62	2.15	1.14	5.13	317.4	2.3
10091 Bandaisan	C18	STL	Clear	Apr 12, 2010	5.03	117	2.24	1.52	21.97	159.3	-3.7
10179 Ishigaki	C18	STL	Clear	Aug 17, 2010	4.67	62	2.26	1.26	4.75	317.4	2.4
(20038) 1992 UN$_5$	C18	STL	Clear	Jan 15, 2010	7.32	255	3.46	2.59	9.03	134	21.8
31956 Wald	1m	PI	Clear	Aug 13, 2010	5.14	90	2.8	1.79	2.38	316.5	2.7
	1m	PI	Clear	Aug 14, 2010	6.72	107	2.8	1.79	2.74	316.6	2.7
(47081) 1998 YV$_9$	C18	STL	Clear	Jul 17, 2010	4.22	47	2.67	1.72	9.72	315.4	1.8
	C18	STL	Clear	Jul 18, 2010	4.71	69	2.66	1.71	9.34	315.5	1.8
	C18	STL	Clear	Jul 19, 2010	4.72	66	2.66	1.7	8.95	315.5	1.8
	C18	STL	Clear	Jul 20, 2010	1.44	22	2.66	1.7	8.59	315.6	1.8
(49574) 1999 CO$_{119}$	C18	STL	Clear	Jan 15, 2010	7.5	261	3	2.12	10.27	132.4	21.3
(61907) 2000 QK$_{230}$	C18	STL	Clear	Jul 18, 2010	4.7	69	2.94	1.99	8.67	316.6	2.2
	C18	STL	Clear	Jul 19, 2010	5.47	73	2.93	1.98	8.32	316.7	2.1
(72693) 2001 FS$_{72}$	C18	STL	Clear	Mar 20, 2010	2.13	49	2.53	1.54	3.89	176.9	6.9
	C18	STL	Clear	Mar 21, 2010	1.89	48	2.53	1.54	4.09	177	6.8
(84944) 2003 WL$_{153}$	C18	STL	Clear	Mar 19, 2010	1.25	33	2.74	1.75	3.46	177	7.2
	C18	STL	Clear	Mar 20, 2010	1.98	51	2.74	1.76	3.62	177	7.3
	C18	STL	Clear	Mar 21, 2010	2.11	49	2.75	1.76	3.84	177	7.3

Table I. Observing circumstances. See the text for an explanation of the columns.

Asteroid name	Period [hours]	U	Amplitude [mag]	H by MPC [mag]
8523 Bouillabaisse	4.4 ± 0.2	+2	0.30 ± 0.03	14.3
10091 Bandaisan	3.23 ± 0.09	+2	0.15 ± 0.05	13.9
10179 Ishigaki	3.34 ± 0.02	3	0.60 ± 0.03	12.7
(20038) 1992 UN$_5$	6.9 ± 0.1	3	0.38 ± 0.03	11.9
31956 Wald	8.90 ± 0.05	+2	0.45 ± 0.05	14.6
(47081) 1998 YV$_9$	7.46 ± 0.03	3	0.20 ± 0.05	14.7
(49574) 1999 CO$_{119}$	6.2 ± 0.1	3	0.5 ± 0.1	13.2
(61907) 2000 QK$_{230}$	6.44 ± 0.05	3	0.6 ± 0.2	14.6
(72693) 2001 FS$_{72}$	2.87 ± 0.01	-2	0.2 ± 0.1	14.1
(84944) 2003 WL$_{153}$	7.3 ± 0.07	2	0.5 ± 0.3	14.5

Table II. Derived periods and amplitudes. The *U* code (reliability) is the suggested value. The value in the Asteroid Lightcurve Database (LCDB, Warner et al., 2009) may differ.

description about reduction, measurements, calibration and analysis.

Lightcurves and spin periods of 10 asteroids, with reliability code of 2 to 3, are reported here. See Warner et al (2009) for a discussion of the "U code" definitions in the Asteroid Lightcurve Database (LCDB). All objects are main-belt asteroids, excluding (20038) 1992 UN$_5$ which belongs to the Hilda group. The absolute magnitudes of these asteroids are in the range of 11.9–14.7 mag. None of the asteroids has published photometric measurements. Since these asteroids were not the prime targets of our observing campaign, they were observed only for one or few nights. Therefore, the spin results, which are averaged on 5.7 hours, are biased against slow-rotators, tumblers, and potential binaries. The results are listed in Table II, which includes the asteroid name, rotation period, reliability code (*U*), photometric amplitude, and the absolute magnitude *H* as appears in the MPC website (*www.cfa.harvard.edu/iau/mpc.html*). The folded lightcurves are presented afterwards on a relative magnitude scale.

Reference

Brosch, N., Polishook, D., Shporer, A., Kaspi, S., Berwald, A. and Manulis, I. (2008). "The Centurion 18 telescope of the Wise Observatory." *Astrophys. Space Sci.* **314**, 163-176.

Harris, A.W., Young, J.W., Scaltriti, F. and Zappalà, V. (1984). "Lightcurves and phase relations of the asteroids 82 Alkmene and 444 Gyptis." *Icarus* **57**, 251-258.

Harris, A.W. and Lupishko, D.F. (1989). "Photometric lightcurve observations and reduction techniques." In *Asteroids II* (R. P. Binzel, T. Gehrels, M. S. Matthews, eds.), pp. 39-53. Univ. of Arizona Press, Tucson.

Polishook, D. and Brosch, N. (2008). "Photometry of Atens – more than a handful of binaries." *Icarus* **194**, 111-124.

Polishook, D. and Brosch, N. (2009). "Photometry and Spin Rate Distribution of Small Main Belt Asteroids." *Icarus* **199**, 319-332.

Polishook, D., Brosch, N., Prialnik D. and Kaspi, S. (2009). "Simultaneous Spectroscopic and Photometric Observations of Binary Asteroids." *Meteoritics & Planetary Science* **44**, p. 1955-1966.

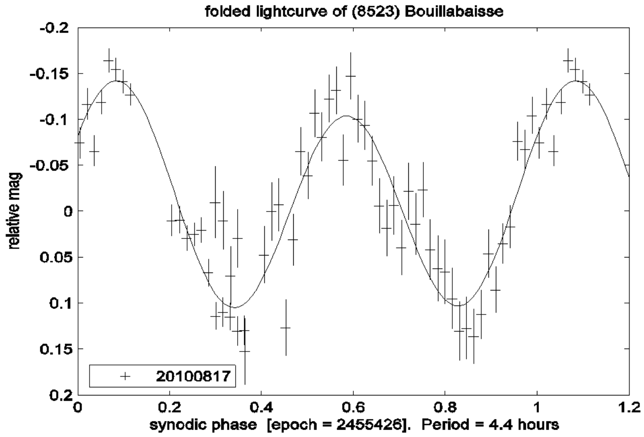
Polishook, D., Brosch, N. And Prialnik D. (2010). "Rotation Periods of Binary Asteroids with Large Separations – Confronting the Escaping Ejecta Binaries Model with Observations." Submitted to *Icarus*.

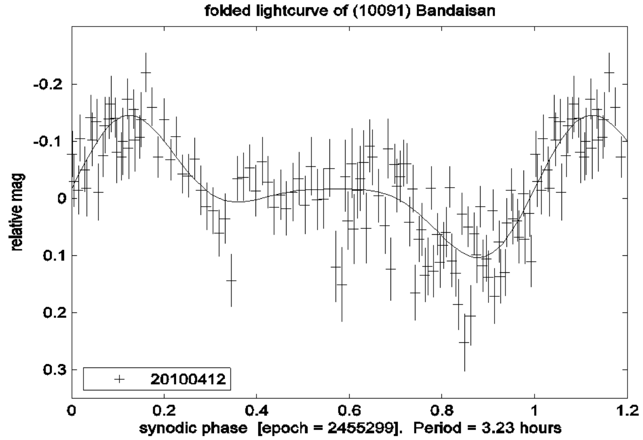
Pravec, P. and 25 colleagues (2010). "Formation of asteroid pairs by rotational fission." *Nature* **466**, p. 1085-1088.

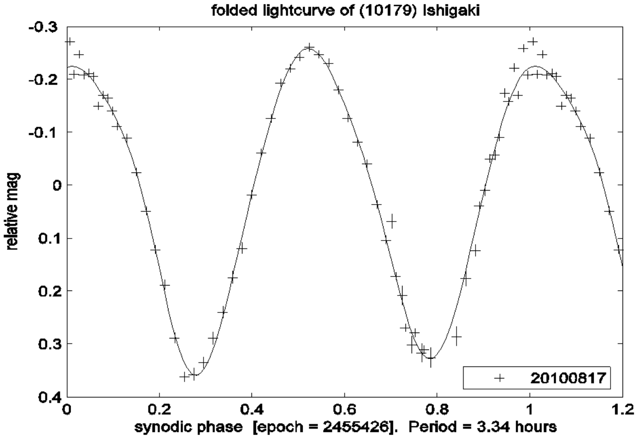
Warner, B.D., Harris, A.W., and Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146.

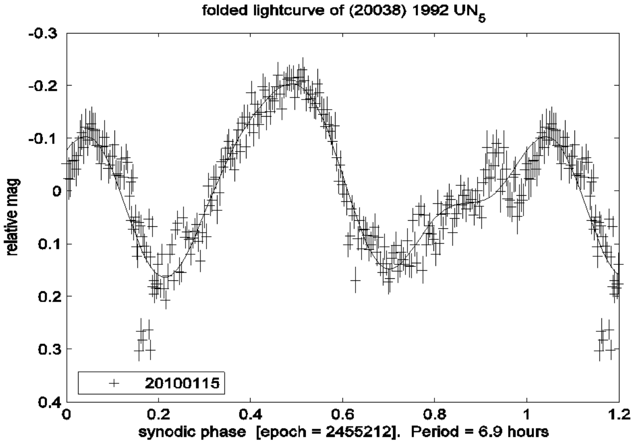
Acknowledgement

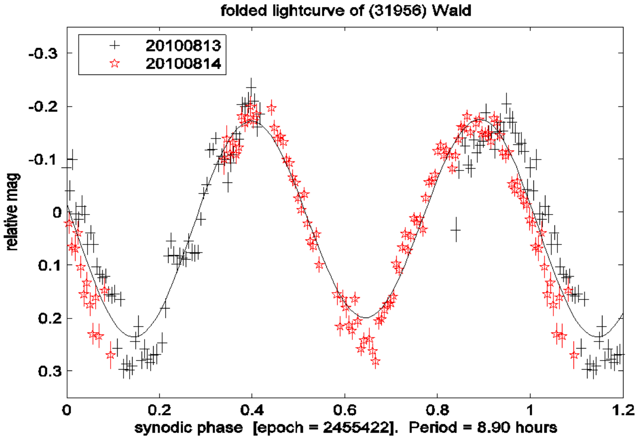
The author is grateful for an *Ilan Ramon* doctoral scholarship from the Israel Space Agency (ISA) and the Ministry of Science. The guidance and help of Dr. Noah Brosch and Prof. Dina Prialnik is always essential. We thank the Wise Observatory staff for their continuous support.

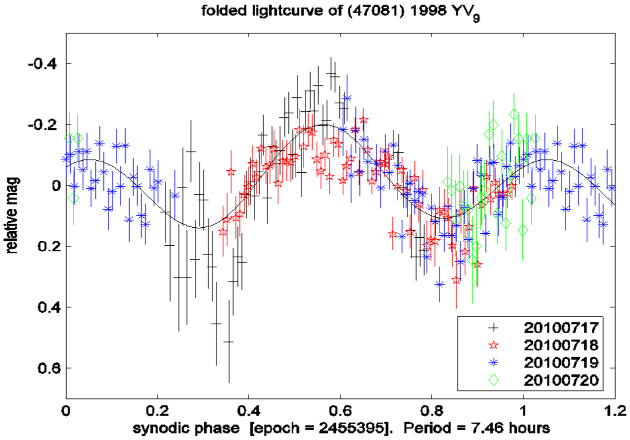


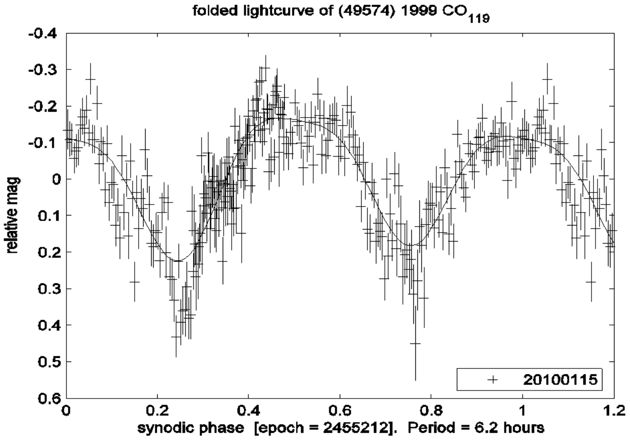


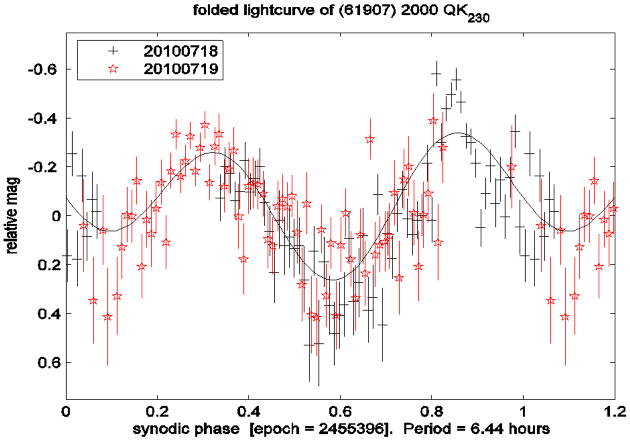


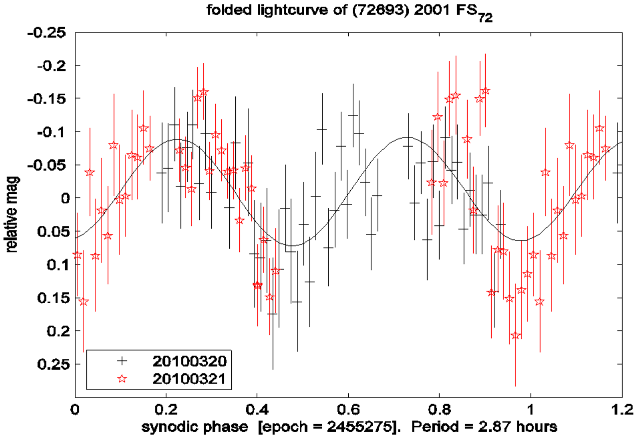


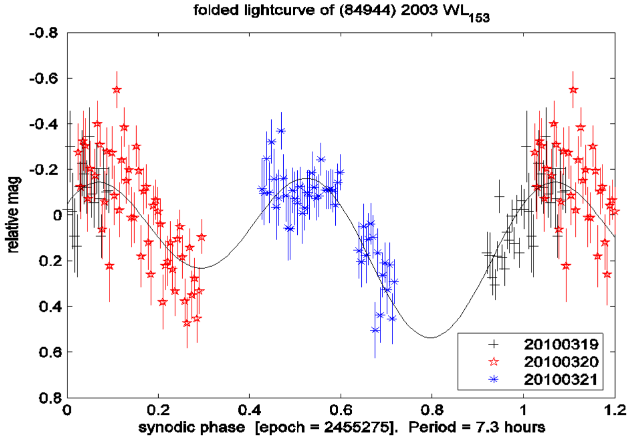












UPON FURTHER REVIEW: III. AN EXAMINATION OF PREVIOUS LIGHTCURVE ANALYSIS FROM THE PALMER DIVIDE OBSERVATORY

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

(Received: 27 September)

Updated results are given for six asteroids previously reported from the Palmer Divide Observatory (PDO). The original images were remeasured 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 were moderately different were found for 860 Ursina, 1146 Biarmia, 1158 Luda, 3431 Nakano, (10936) 1998 FN11, and (11424) 1999 LZ24. This is the third in a series of papers that examines 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 (ca 1999-2006). In most cases, any changes in the period and/or amplitude as a result of the new analysis were statistically insignificant. Some, however, fit into a gray area between significant and not but are still worth noting. This paper is the third in a series that reports updated results from the initial stage of new analysis, in this case giving updates on six asteroids that fit into that gray area. Subsequent stages will likely produce additional revisions.

For background on the justification and methodology of this project, see the first paper in the series (Warner, 2010).

Presentation of the New Analysis

A brief analysis of the new data set and lightcurve based on that new data set are given below, 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 higher rating; see Warner et al., 2009, for information about the U code rating system). The exact observing details will not be given. Instead, a table lists the original and new results along with a reference to the original

		Original				Revised				
#	Name	Per	Amp	U	Ref	Per	PE	Amp	AE	U
860	Ursina	9.386	0.22	3	Warner; MPB 27, 4-6	9.32	0.01	0.24	0.01	3-
1146	Biarmia	11.514	0.32	2	Warner; MPB 27, 4-6	5.33	0.01	0.21	0.01	2
1158	Luda	6.90	0.15	2	Warner; MPB 32, 54-58	6.870	0.005	0.18	0.01	3
3431	Nakano	8.90	0.25	2	Warner; MPB 30, 61-64	9.2	0.1	0.24	0.02	2
10936	1998 FN11	17.3[1]	0.35	2	Warner; MPB 35, 67-71	17.0[2]	0.02	0.28	0.02	2
11424	1999 LZ24	2.925	0.11	2	Warner; MPB 28, 30-32	2.925	0.005	0.08	0.01	3

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.

[1] Ambiguous; 26.6 h also possible.

[2] Ambiguous; 25.7 h also possible.

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).

860 Ursina. The original data set was given too generous of review. The revised period has a lesser precision and slightly lower U rating.

1146 Biarmia. The original period of 11.5 h appears to be double the true period. The revised result of 5.33 h is in better agreement with a much better data set and determination by Durkee (2009).

1158 Luda. The revised data set included additional points and the confidence of using an internal standard for linking the four nights.

3431 Nakano. The new result is a slightly longer period. However, even the revised data set is too sparse to give a very precise period.

(10936) 1998 FN11. Two solutions with a bimodal curve are possible. The revised data changed the period solution slightly but didn’t provide any greater confidence.

(11424) 1999 LZ24. The period did not change with the new data set but the quality was significantly improved by having more data points and confidence in the linking of the three sessions.

Acknowledgements

Funding for observations and research at the Palmer Divide Observatory is currently provided by NASA grant NNX 10AL35G, by National Science Foundation grant AST-1032896 and by a 2007 Gene Shoemaker NEO Grant from the Planetary Society.

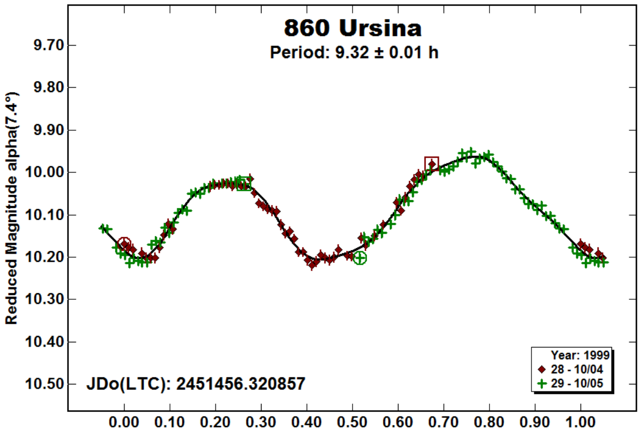
References

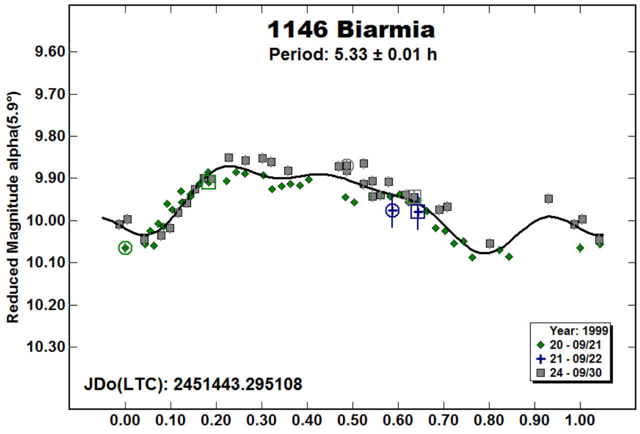
Durkee, R.I. (2009). “The Lightcurves of 1146 Biarmia and 5598 Carlmurray.” *Minor Planet Bul.* **36**, 170.

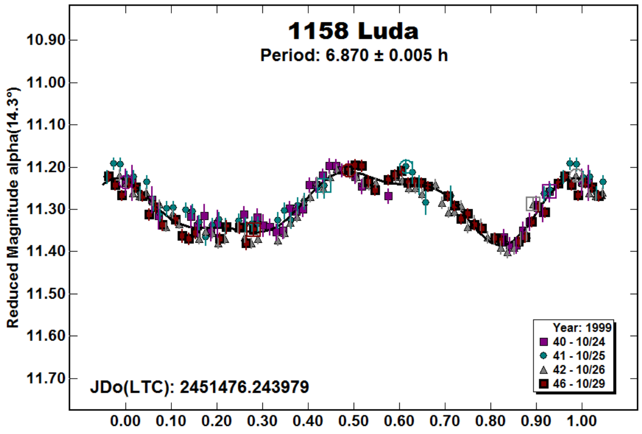
Pravec, P., Wolf, M., and Sarounova, L. (2010). “Ondrejov Asteroid Photometry Project” website:
http://www.asu.cas.cz/~ppravec/neo.htm

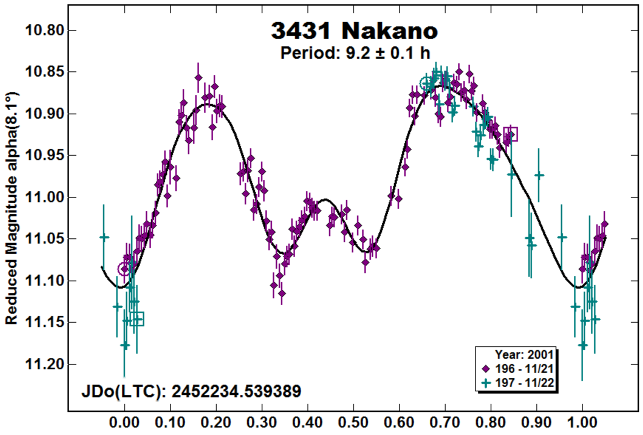
Warner, B.D., Harris, A.W., and Pravec, P. (2009c) “The Asteroid Lightcurve Database.” *Icarus* **202**, 134-146.

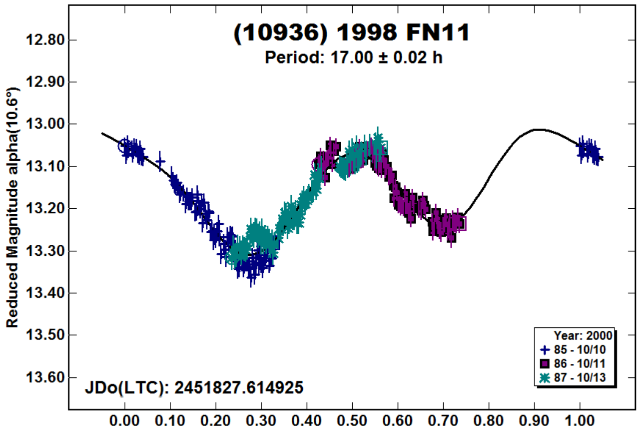
Warner, B.D. (2010). “Upon Further Review: I. An Examination of Previous Lightcurve Analysis from the Palmer Divide Observatory.” *Minor Planet Bulletin* 37, 127-130.

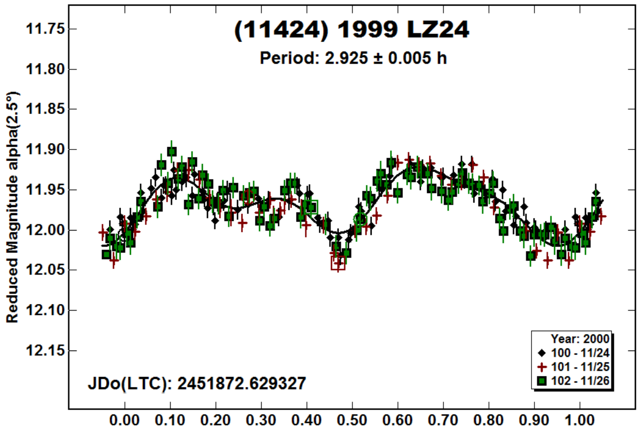












ASTEROIDS OBSERVED FROM GMARS AND SANTANA OBSERVATORIES: 2010 JULY - SEPTEMBER

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

(Received: 29 September)

Lightcurves of four asteroids were obtained from Santana and GMARS Observatories from 2010 July to September: 370 Modestia, 938 Chlosinde, 1619 Ueta, 2650 Elinor.

The asteroids were selected from the list of asteroid photometry opportunities published on the Collaborative Asteroid Lightcurve Link (CALL) website (Warner et al., 2010). Observations 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 with no filter. 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 (1989).

The results are summarized in the table below. 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. 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).

370 Modestia. Images on 08/04 were taken at GMARS. All others were taken at Santana Observatory. Based upon a single night's observations in March 2007, Behrend (2010) reported the period was greater than 20 h. Monson (2004) reported a single session on August 2, 2003 but did not report a period.

938 Chlosinde. A search of the Asteroid Lightcurve Data File (Warner 2010) did not reveal any previously reported periods. Images on 09/03 were obtained at GMARS. All others were at Santana Observatory.

1619 Ueta. All images were obtained at GMARS. Addleman (2005) reported a single night observations, but did not determine a period. Almeida (2004) obtained a single night of sparse observations on September 22, 2000 determining a period of 2.94 ± 0.01 hours. That result is in fair agreement with this denser set of observations.

2650 Elinor. Images on 09/06 and 09/19 were obtained at Santana Observatory. Images on 09/10 were obtained at GMARS. Behrend (2010) reported a period of 9.087 hours with an amplitude of 0.12 magnitudes using partial lightcurves obtained on November 19, 2006 and March 2, 2007. There was substantial scatter in the data points on both nights.

References

Almeida, R., Angeli, C.A., Duffard, R., and Lazzaro, D. (2004). *Astron. Astrophys.* **415**, 403-406.

Addleman, D., Covele, B., Duncan, A., Johnson, J., et al. (2005). *Minor Planet Bul.* **32**, 76-78.

Behrend, R., (2010). Observatoire de Geneve web site,*http://obswww.unige.ch/~behrend/page_cou.html.*

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

Monson, A. and Kipp, S. (2004). *Minor Planet Bul.* **31**, 71-73; corr. *Minor Planet Bul.* **31**, 97

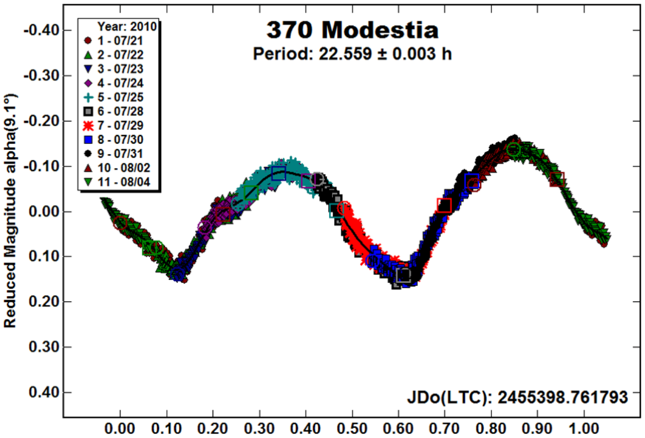
#	Name	mm/dd 2010	Data	α	L_{PAB}	B_{PAB}	Per(h)	PE	A(mag)	AE
370	Modestia	07/21 - 08/04	2,092	9.2, 2.9	313	4	22.559	0.003	0.27	0.03
938	Chlosinde	08/23 - 09/03	1,321	6.1, 1.5	342	-2	19.204	0.006	0.14	0.03
1619	Ueta	09/04 - 09/06	261	13.8, 12.9	1	-9	2.720	0.005	0.38	0.02
2650	Elinor	09/07 - 09/11	488	13.9, 12.3	6	9	2.762	0.001	0.18	0.03

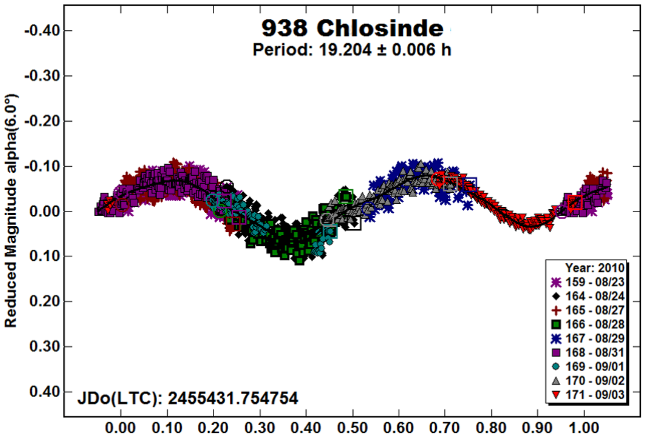
Stephens, R.D. (2008). “Long Period Asteroids Observed from GMARS and Santana Observatories.” *Minor Plan. Bul*. **35**, 31-32.

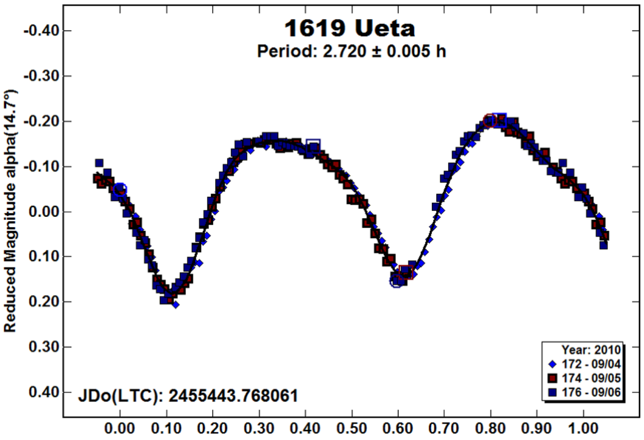
Warner, B.D. (2007). “Initial Results from a Dedicated H-G Project.” *Minor Planet Bul.* **34**, 113-119.

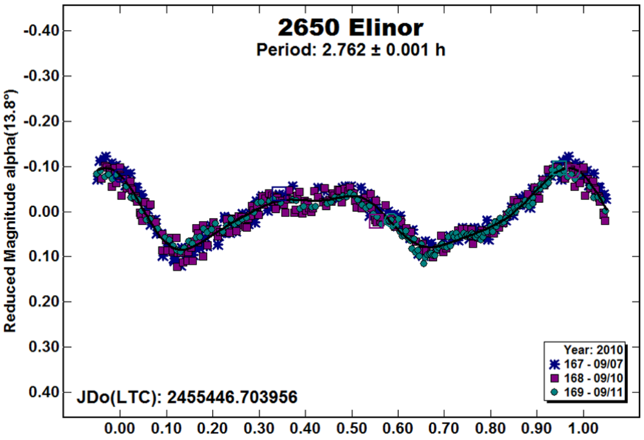
Warner, B.D., Harris, A.W., and Pravec, P. (2010). Asteroid Lightcurve Data File, *http://www.MinorPlanetObserver.com/astlc/LightcurveParameters.htm.*

Warner, B.D., Harris, A.W., and Pravec, P. (2010). Lightcurve Targets *http://www.MinorPlanetObserver.com/astlc/default.htm.*









LIGHTCURVE ANALYSIS OF 1211 BRESSOLE

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

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

(Received: 29 September)

Observations of the main-belt asteroid 1211 Bressole at Santana Observatory and Palmer Divide Observatory in June and July 2010 found a synodic period of 31.812 ± 0.004 h and an amplitude of 0.56 ± 0.05 mag.

Initial observations of 1211 Bressole were made at Santana Observatory (MPC Code 646). See Stephens (2010) for a general description of Santana equipment and analysis methods. Because Stephens left on a trip to view the July 2010 total solar eclipse, a request was made to Warner at Palmer Divide Observatory to obtain observations to fill in a missing maximum. See Warner (2010) for a general description of equipment at PDO. See Warner (2007) and Stephens (2008) for details on data set calibration and linking using 2MASS to BVRI conversions.

A search of the Asteroid Lightcurve Data file (Warner, 2010) did not reveal any previously reported periods. The final data set of 1,054 data points spanned 40 days. Analysis of the lightcurve determined a synodic period of 31.812 ± 0.004 h and an amplitude of 0.56 ± 0.05 mag.

Acknowledgements

Funding of observations at the Palmer Divide Observatory is provided by NASA grant NNX10AL35G, by National Science Foundation grant AST-1032896, and by a 2007 Gene Shoemaker NEO Grant from the Planetary Society.

References

Stephens, R.D. (2008). “Long Period Asteroids Observed from GMARS and Santana Observatories.” *Minor Plan. Bul*. **37**, 31-32.

Stephens, R.D. (2010). “Asteroids Observed from GMARS and Santana Observatories: 2010 July-September.” *Minor Planet Bul.* **37**, 159-161.

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

Warner, B.D. (2010). “Asteroid Lightcurve Analysis at the Palmer Divide Observatory: 2009 September-December.” *Minor Planet Bul.* **37**, 57-64.

Warner, B.D., Harris, A.W., and Pravec, P. (2010). Asteroid Lightcurve Data file, *http://www.MinorPlanetObserver.com/astlc/LightcurveParameters.htm.*

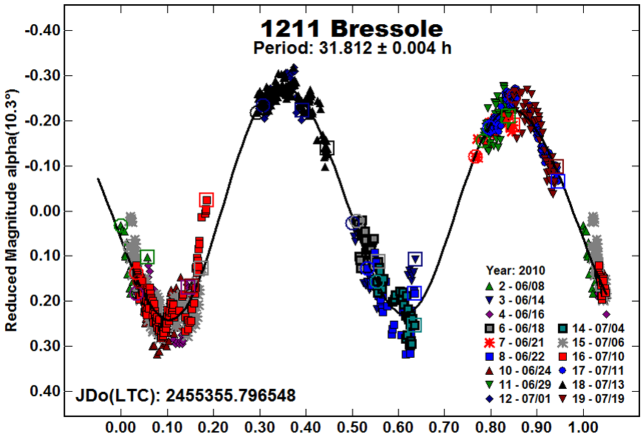


Figure 1. Lightcurve of 1211 Bressole. α = 10.3 to 4.0, L_{PAB} = 279, B_{PAB} = 8.

ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY: 2010 JUNE–SEPTEMBER

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

(Received: 29 September Revised: 19 November)

Lightcurves for 30 asteroids were obtained at the Palmer Divide Observatory (PDO) from 2010 June through September: 1373 Cincinnati, 2642 Vesale, 2860 Pasacentennium, 3387 Greenberg, 4116 Elachi, 4440 Tchantches, 4483 Petofi, 4674 Pauling, 5175 Ables, 5968 Trauger, 6087 Lupo, 6163 Reimers, 7087 Lewotsky, 7173 Sepkoski, (11058) 1991 PN10, 15964 Billgray, (21688) 1999 RK37, (33203) 1998 FA57, (45436) 2000 AD176, (46559) 1991 PC1, (49675) 1999 SW27, (49678) 1999 TQ7, (57219) 2001 QY71, (66193) 1999 AF22, (76864) 2000 XR13, (76929) 2001 AX34, (82060) 2000 WX8, (102063) 1999 RR134, (174633) 2003 SM110, and 2006 WL15.

CCD photometric observations of 30 asteroids were made at the Palmer Divide Observatory (PDO) from 2010 June through September. 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 by applying –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, e.g., alpha(6.5°), using $G = 0.15$ unless otherwise stated.

1313 Cincinnati. Warner (2005) and Behrend (2010) reported periods of $P \sim 5.28$ h based on observations in 2004. New data obtained at PDO in 2010 could not be fit to that period, instead finding $P = 4.930 \pm 0.001$ h. The period spectra from using the 2004 and 2010 data are shown below. Forcing the data from one epoch to the period of the other produces unacceptable results. Additional observations are needed.

2642 Versale. Wisenewski et al. (1997) observed this asteroid in 1987 and reported a period of 7.246 h. The 2010 data from PDO found a period of 5.566 h. Alan Harris (*private communication*) reviewed the original Wisknewski data and determined that the new, shorter period is likely correct.

2860 Pasacentennium. The results here agree with those found by Behrend (2010).

4116 Elachi. Warner (2006) found a period of 38.12 h. The 2010 data give similar results.

4440 Tchantches. The 2010 data represent the fourth apparition at which this asteroid was observed at the PDO (Warner *et al.*, 2006b; Warner and Higgins, 2009). The latest results give P = 2.790 h, in good agreement the periods reported from 2005 and 2009. A review of the 2002 data showed that the originally reported period of P = 6.83 h (Warner, 2003) was incorrect and that the 2002 data provided a good fit to a period of P = 2.783 h.

4483 Petofi. This Hungaria asteroid was previously worked by Angeli and Barucci (1996, P = 4.480 h), Wisnewski *et al.* (1997, P = 4.4 h), Brinsfield (2008, P = 4.33 h), and Warner (2008, 2009a; $P \sim 4.334$ h). The 2010 PDO observations found P = 4.3335 h.

4674 Pauling. This is a known binary asteroid discovered with adaptive optics (Merline *et al.*, 2004). The 2010 PDO observations found P = 2.533 h, which is in agreement with previous results (Warner, 2006b; Behrend, 2010).

5968 Trauger. Warner (2006a) reported a period of 7.560 h. A re-examination of the 2005 data favored a half-period of P = 3.783 h with an amplitude of 0.10 mag. In 2010, the amplitude of the curve was 0.36 mag, which was hoped would lead to a definitive period solution. However, the derived period of 6.341 h is well-removed from the solutions based on the 2005 data. Neither data set can be reasonably fit to the period found using the other. Given the larger amplitude in 2010, the 6.341 h solution is considered more likely but not conclusive.

7087 Lewotsky. Carbo *et al.* (2009) reported an amplitude of 0.25 mag but no period. The PDO data give a period of 5.15 h and amplitude of 0.12 mag. However, the curve is noisy and the period solution is still not definitive.

#	Name	mm/dd 2010	Data Pts	α	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (mag)	AE
1373	Cincinnati (H)	08/21-09/06	153	11.2,14.2	323	27	4.930	0.001	0.11	0.01
2642	Vesale	08/21-08/27	181	10.9,11.2	328	17	5.566	0.005	0.12	0.01
2860	Pasacentennium	09/24-09/25	137	13.6	8	18	2.660	0.005	0.17	0.02
3387	Greenberg	08/21-08/29	295	10.5	332	17	2.6941	0.0003	0.10	0.01
4116	Elachi (H)	09/07-09/14	380	13.8,15.7	332	17	38.3	0.1	1.04	0.03
4440	Tchantches (H)	08/11-08/14	172	17.4,16.8	337	23	2.790	0.001	0.28	0.02
4483	Petofi (H)	08/13-09/05	237	22.2,12.8	343	18	4.3335	0.0001	0.86-1.03	0.02
4674	Pauling (H)	09/09-09/11	175	17.6	354	26	2.533	0.003	0.05	0.01
5175	Ables (H)	09/01-09/04	270	23.1,22.2	16	17	2.798	0.002	0.10	0.01
5968	Trauger (H)	06/19-07/10	78	25.1,22.0	294	33	6.341	0.002	0.36	0.02
6087	Lupo (H)	07/11-07/16	133	20.2,17.9	316	14	4.712	0.003	0.66	0.02
6163	Reimers (H)	09/06/09/07	145	27.5	20	14	6.68	0.01	1.22	0.02
7087	Lewotsky (H)	08/15-08/26	177	22.0,18.8	358	22	5.15	0.02	0.12	0.03
7173	Sepkoski (H)	09/09-09/25	250	19.3,17.9	357	27	2.4996	0.0003	0.09	0.01
11058	1991 PN10	07/17-07/20	110	22.2,21.0	320	20	6.517	0.005	0.47	0.02
15964	Billgray	09/07-09/10	155	12.7	348	17	3.571	0.003	0.45	0.02
21688	1999 RK37 (H)	09/03-09/26	361	29.3,24.9	22	26	5.6960	0.0005	0.80	0.02
33203	1998 FA57	09/15	59	6.3	8	-1	3.0	0.1	0.26	0.03
45436	2000 AD176	06/18-07/06	138	19.7,22.7	228	16	18.47	0.04	1.15	0.05
46559	1991 PC1 (H)	09/12-09/14	149	10.1,9.1	2	6	5.168	0.005	0.56	0.02
49675	1999 SW27 (H)	08/31-09/02	155	19.8	2	25	4.994	0.005	0.40	0.02
49678	1999 TQ7 (H)	09/12-09/14	153	5.2,4.3	352	6	3.957	0.005	0.40	0.03
57219	2001 QY71	09/27-09/28	115	1.7,1.2	7	0	2.885	0.003	0.28	0.02
66193	1999 AF22	09/12-09/26	153	4.2,4.0,6.4	353	6	8.00	0.01	0.26	0.03
76864	2000 XR13 (H)	08/27-09/02	177	19.2,20.6	327	26	3.892	0.003	0.16	0.02
76929	2001 AX34 (H)	09/01-09/07	439	11.5,10.1	349	11	36.4	0.5	0.03	0.01
82060	2000 WX8 (H)	08/15-08/31	178	20.6,23.3	315	16	2.7631	0.0005	0.32	0.02
102063	1999 RR134	09/13-09/16	156	3.1	352	6	7.53	0.02	0.11	0.02
174633	2003 SM110	09/13-09/15	149	4.5	352	6	3.579	0.005	0.19	0.02
	2006 WL15	09/16	24	9.1	6	0	? 6.		0.25	

Table II. Observing circumstances. Asteroids with "(H)" after the name are members of the Hungaria group. The phase angle (α) 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).

(33203) 1998 FA57. As often happens near the equinoxes, a number of secondary targets can be found in the same field as a primary target. Eventually, circumstances and resources limit which secondary targets can be followed for the necessary amount of time. This outer main-belt asteroid was in the same field as a primary target on one night and could not be worked additional nights. The 0.26 mag. amplitude allows some confidence in the period solution of 3.0 ± 0.1 h.

(76864) 2000 XR13. This Hungaria was previously observed by Warner (2009b), when a period of 3.89 h was found. The 2010 observations confirmed that period. The data from Aug 27 showed what appeared to be a mutual event (occultation or eclipse) due to a satellite. The asteroid was observed on the following six nights but a confirming observation was never made. The images were re-measured and the "event" was confirmed; its cause remains unknown.

(76929) 2001 AX34. The 2010 data alone did not reveal a definitive solution due to a lightcurve amplitude of only 0.03 mag. The results from a previous apparition (P = 36.2 h, A = 0.19 mag; Warner, 2009c) were used to constrain the solution for 2010.

2006 WL15. This was one of two secondary targets on one night. The other, 11118 Modra, was brighter and kept on the observing list while this one suffered the fate of being "one too many". The lightcurve shows only the raw data, although a rough estimate of 6 h was made on the assumptions of a bimodal curve and that, presumably, about one-quarter of a cycle was observed.

Acknowledgements

Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNX10AL35G, by National Science Foundation grant AST-1032896, and by a 2007 Gene Shoemaker NEO Grant from the Planetary Society.

References

Angeli, C.A. and Barucci, M.A. (1996). "CCD observations: rotational properties of 13 small asteroids." *Planet. Space Sci.* **44**, 181-186.

Behrend, R. (2010). Observatoire de Geneve web site, *http://obswww.unige.ch/~behrend/page_cou.html*

Brinsfield, J.W. (2008). "The Rotation Periods of 1465 Autonoma, 1656 Suomi 4483 Petofi, 4853 Marielukac, and (85275) 1994 LY." *Minor Planet Bul.* **35**, 23-24.

Carbo, L., Green, D., Kragh, K., Krotz, J., Meiers, A., Patino, B., Pligge, Z., Shaffer, N., and Ditteon, R. (2009). "Asteroid Lightcurve Analysis at the Oakley Southern Sky Observatory: 2008 October thru 2009 March." *Minor Planet Bul.* **36**, 152-157.

Durech, J., Kaasalainen, M., Warner, B. D., Fauerbach, M., Marks, S. A., Fauvaud, S., Fauvaud, M., Vugnon, J.-M., Pilcher, F., Bernasconi, L., and Behrend, R. (2009). "Asteroid models from combined sparse and dense photometric data." *Astron. Astrophys.* **493**, 291-297.

Masi, G., Foglia, S., and Binzel, R.P. (2008). "Search for unusual spectroscopic candidates among 40313 minor planets from the 3rd release of the Sloan Digital Sky Survey Moving Object Catalog." Astron. Astrophys, submitted.

Merline, W. J., Tamblyn, P. M., Dumas, C., Menard, F., Close, L. M., Chapman, C. R., Duvert, G., and Ageorges, N. (2004). "S/2004 (4674) 1." *IAUC* **8297**.

Warner, B.D. (2003). "Lightcurve analysis for asteroids 607 Jenny, 1177 Gonnessia 4440 Tchantches, 4896 Tomoegozen, and (4995) 1984 QR." *Minor Planet Bul.* **30**, 33-35.

Warner, B.D. (2005). "Lightcurve analysis for asteroids 242, 893, 921, 1373, 1853, 2120, 2448 3022, 6490, 6517, 7187, 7757, and 18108." *Minor Planet Bul.* **32**, 4-7.

Warner, B.D. (2006a). "Asteroid lightcurve analysis at the Palmer Divide Observatory: July-September 2005." *Minor Planet Bul.* **33**, 35-39.

Warner, B.D., Pravec, P., Kusnirák, P., Foote, C., Foote, J., Galád, A., Gajdos, S., Kornos, L., Világi, J., Higgins, D., Nudds, S., Kugly, Y.N., and Gaftonyuk, N.M. (2006b). "Lightcurves analysis for Hungaria asteroids 3854 George, 4440 Tchantches and 4674 Pauling." *Minor Planet Bul.* **33**, 34-35.

Warner, B.D. (2008). "Asteroid Lightcurve Analysis at the Palmer Divide Observatory - June - October 2007." *Minor Planet Bul.* **35**, 56-60.

Warner, B.D. (2009a). "Asteroid Lightcurve Analysis at the Palmer Divide Observatory: 2009 March-June." *Minor Planet Bul.* **36**, 172-176.

Warner, B.D. (2009b). "Asteroid Lightcurve Analysis at the Palmer Divide Observatory: 2008 September-December." *Minor Planet Bul.* **36**, 70-73.

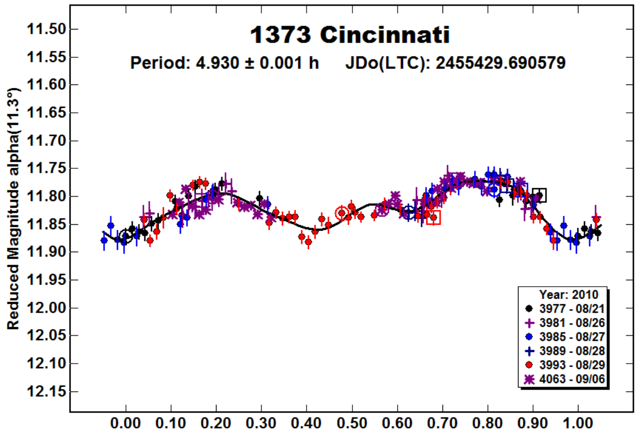
Warner, B.D. (2009c). "Asteroid Lightcurve Analysis at the Palmer Divide Observatory: 2008 December - 2009 March." *Minor Planet Bul.* **36**, 109-116.

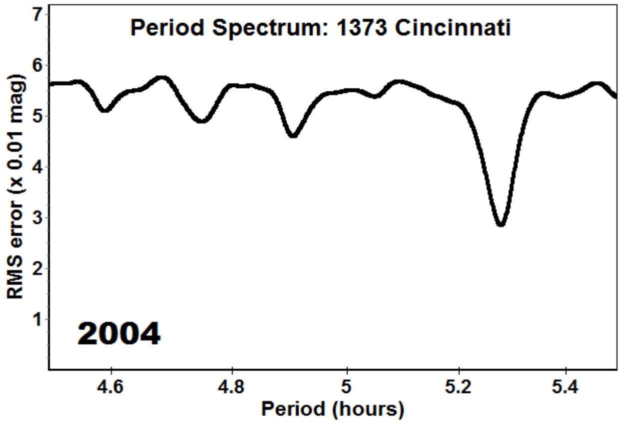
Warner, B.D., Harris, A.W., Vokrouhlický, D., Nesvorný, D., and Bottke, W.F. (2009). "Analysis of the Hungaria asteroid population." *Icarus* **204**, 172-182.

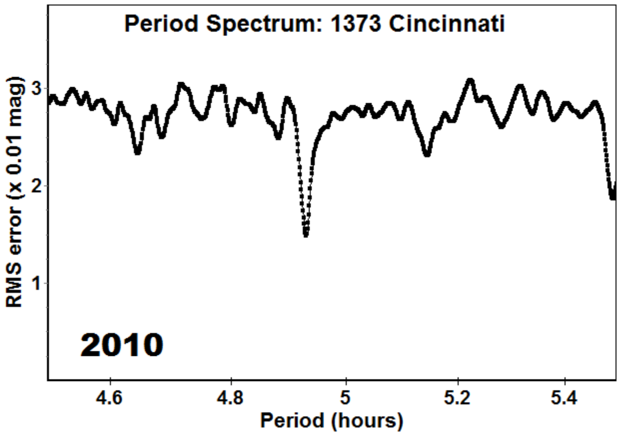
Warner, B.D. and Higgins, D. (2009). "Lightcurve Analysis of Hungaria Asteroid 4440 Tchantches." *Minor Planet Bul.* **36**, 90.

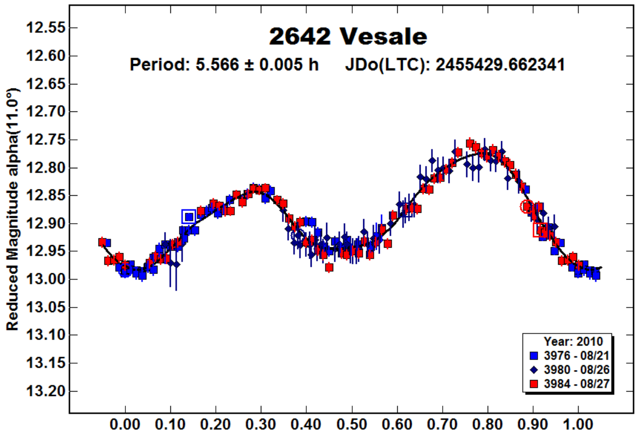
Warner, B.D. (2010). "Asteroid Lightcurve Analysis at the Palmer Divide Observatory: 2009 June-September." *Minor Planet Bul.* **37**, 24-27.

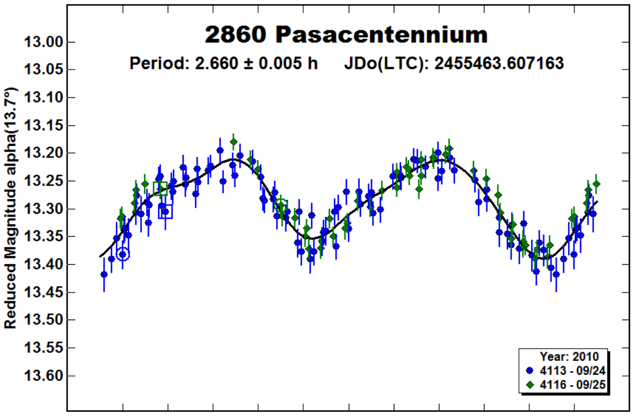
Wisniewski, W.Z., Michalowski, T.M., Harris, A.W., and McMillan, R.S. (1997). "Photometric Observations of 125 Asteroids." *Icarus* **126**, 395-449.

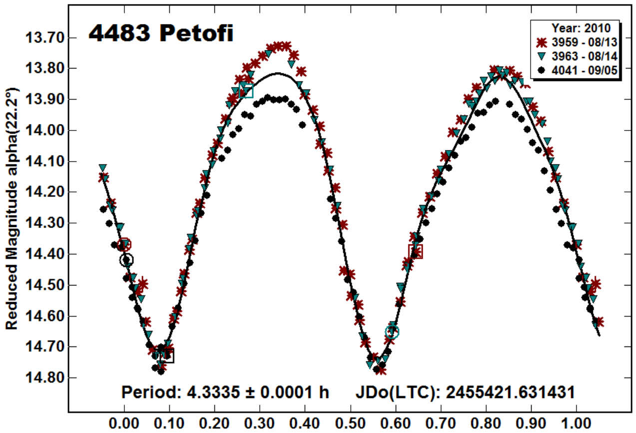


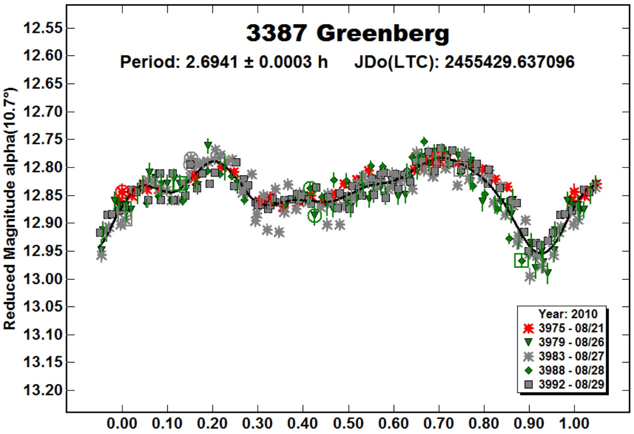


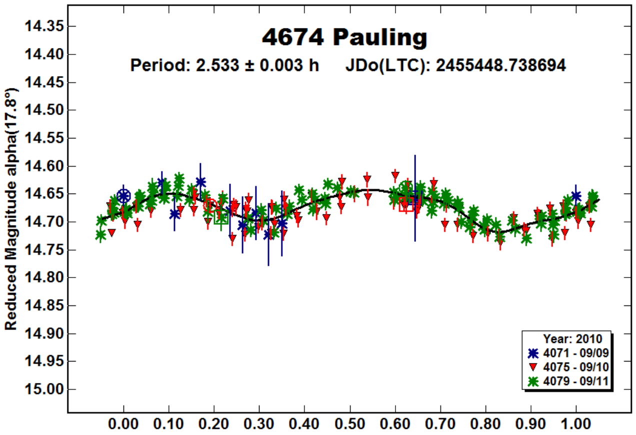


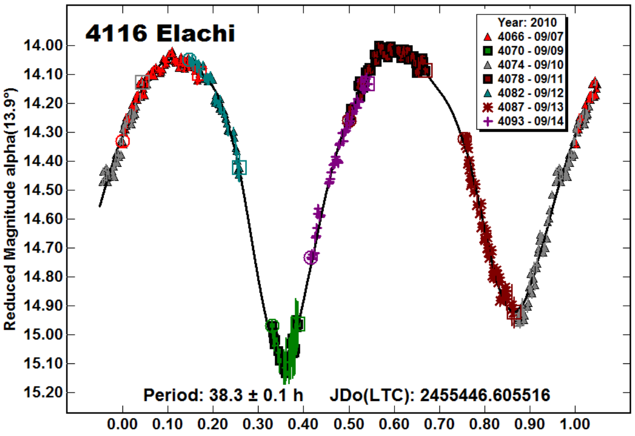


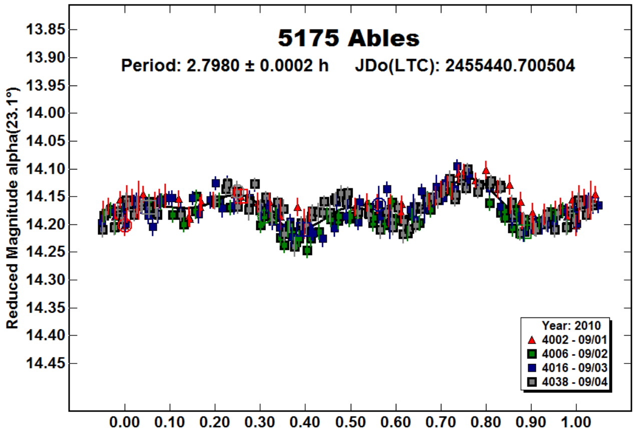

2860 Pasacentennium
Period: 2.660 ± 0.005 h JDo(LTC): 2455463.607163
Reduced Magnitude alpha(13.7°)
13.00 13.05 13.10 13.15 13.20 13.25 13.30 13.35 13.40 13.45 13.50 13.55 13.60
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Year: 2010
4113 - 09/24
4116 - 09/25

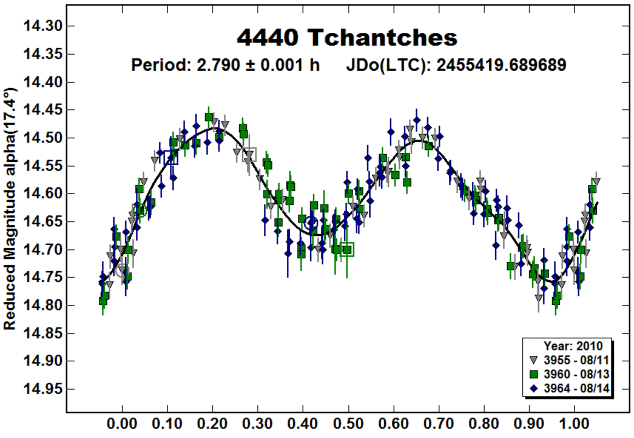

4483 Petofi
Year: 2010
3959 - 08/13
3963 - 08/14
4041 - 09/05
Reduced Magnitude alpha(22.2°)
13.70 13.80 13.90 14.00 14.10 14.20 14.30 14.40 14.50 14.60 14.70 14.80
Period: 4.3335 ± 0.0001 h JDo(LTC): 2455421.631431
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

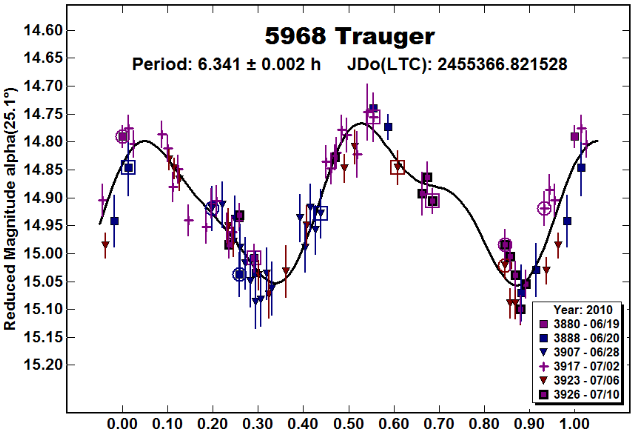

3387 Greenberg
Period: 2.6941 ± 0.0003 h JDo(LTC): 2455429.637096
Reduced Magnitude alpha(10.7°)
12.55 12.60 12.65 12.70 12.75 12.80 12.85 12.90 12.95 13.00 13.05 13.10 13.15 13.20
Year: 2010
3975 - 08/21
3979 - 08/26
3983 - 08/27
3988 - 08/28
3992 - 08/29
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

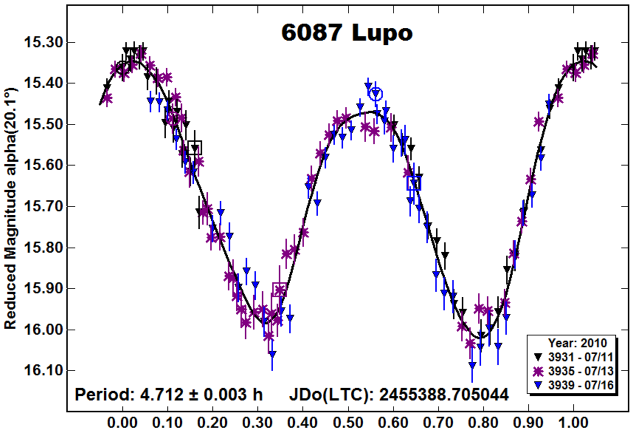

4674 Pauling
Period: 2.533 ± 0.003 h JDo(LTC): 2455448.738694
Reduced Magnitude alpha(17.8°)
14.35 14.40 14.45 14.50 14.55 14.60 14.65 14.70 14.75 14.80 14.85 14.90 14.95 15.00
Year: 2010
4071 - 09/09
4075 - 09/10
4079 - 09/11
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

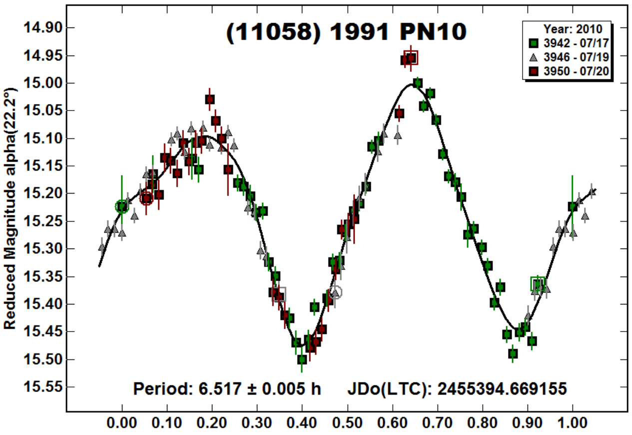

4116 Elachi
Year: 2010
4066 - 09/07
4070 - 09/09
4074 - 09/10
4078 - 09/11
4082 - 09/12
4087 - 09/13
4093 - 09/14
Reduced Magnitude alpha(13.9°)
14.00 14.10 14.20 14.30 14.40 14.50 14.60 14.70 14.80 14.90 15.00 15.10 15.20
Period: 38.3 ± 0.1 h JDo(LTC): 2455446.605516
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

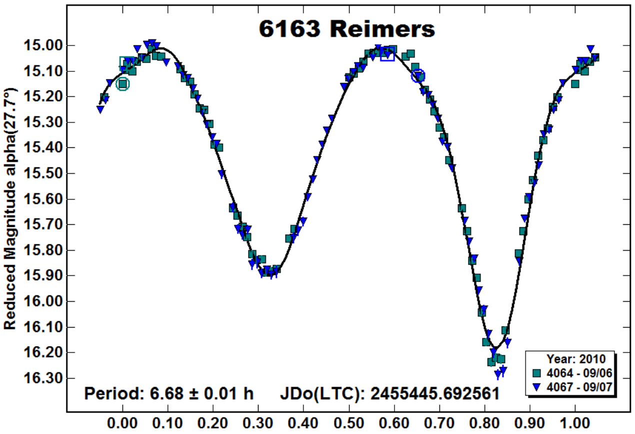

5175 Ables
Period: 2.7980 ± 0.0002 h JDo(LTC): 2455440.700504
Reduced Magnitude alpha(23.1°)
13.85 13.90 13.95 14.00 14.05 14.10 14.15 14.20 14.25 14.30 14.35 14.40 14.45
Year: 2010
4002 - 09/01
4006 - 09/02
4016 - 09/03
4038 - 09/04
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

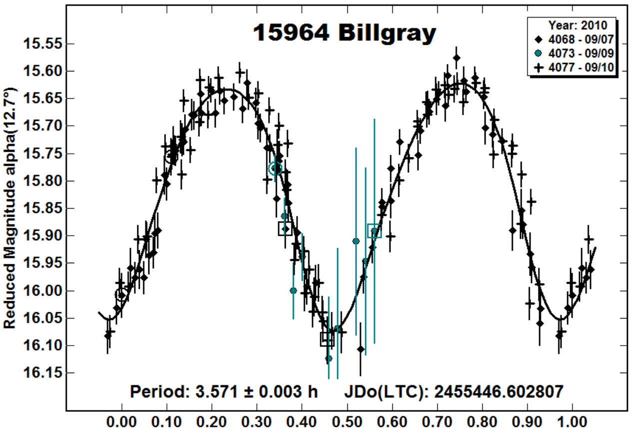

4440 Tchantches
Period: 2.790 ± 0.001 h JDo(LTC): 2455419.689689
Reduced Magnitude alpha(17.4°)
14.30 14.35 14.40 14.45 14.50 14.55 14.60 14.65 14.70 14.75 14.80 14.85 14.90 14.95
Year: 2010
3955 - 08/11
3960 - 08/13
3964 - 08/14
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

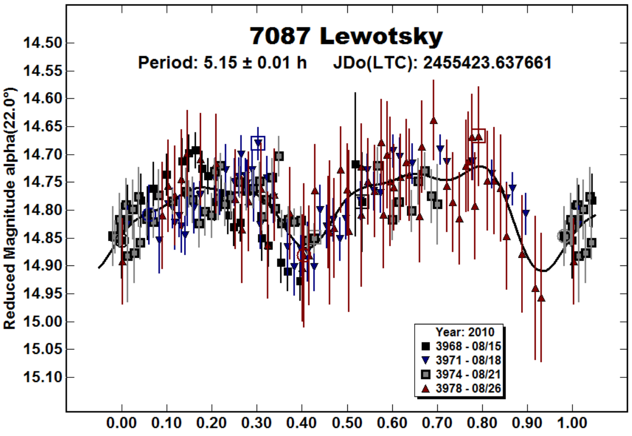

5968 Trauger
Period: 6.341 ± 0.002 h JDo(LTC): 2455366.821528
Reduced Magnitude alpha(25.1°)
14.60 14.65 14.70 14.75 14.80 14.85 14.90 14.95 15.00 15.05 15.10 15.15 15.20
Year: 2010
3880 - 06/19
3888 - 06/20
3907 - 06/28
3917 - 07/02
3923 - 07/06
3926 - 07/10
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

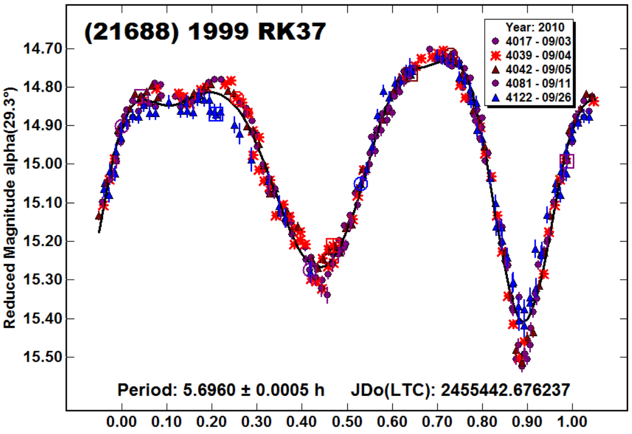

6087 Lupo
Reduced Magnitude alpha(20.1°)
15.30
15.40
15.50
15.60
15.70
15.80
15.90
16.00
16.10
Year: 2010
3931 - 07/11
3935 - 07/13
3939 - 07/16
Period: 4.712 ± 0.003 h
JDo(LTC): 2455388.705044
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

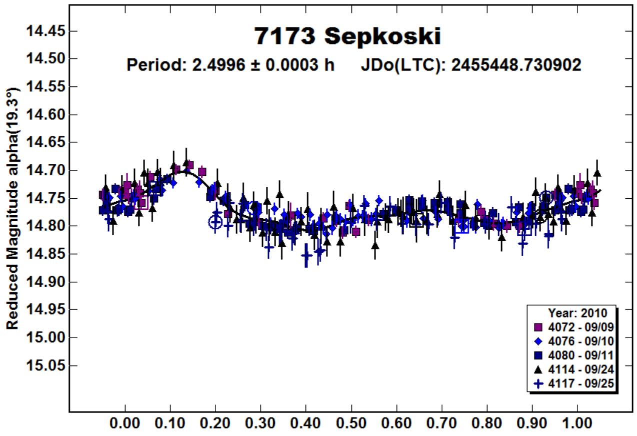

(11058) 1991 PN10
Year: 2010
3942 - 07/17
3946 - 07/19
3950 - 07/20
Reduced Magnitude alpha(22.2°)
14.90
14.95
15.00
15.05
15.10
15.15
15.20
15.25
15.30
15.35
15.40
15.45
15.50
15.55
Period: 6.517 ± 0.005 h
JDo(LTC): 2455394.669155
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

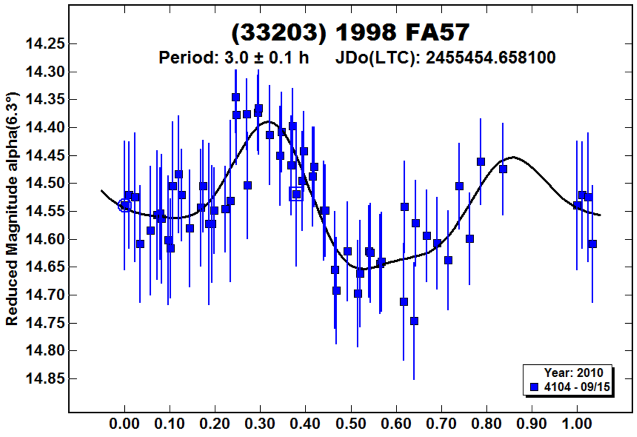

6163 Reimers
Reduced Magnitude alpha(27.7°)
15.00
15.10
15.20
15.30
15.40
15.50
15.60
15.70
15.80
15.90
16.00
16.10
16.20
16.30
Year: 2010
4064 - 09/06
4067 - 09/07
Period: 6.68 ± 0.01 h
JDo(LTC): 2455445.692561
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

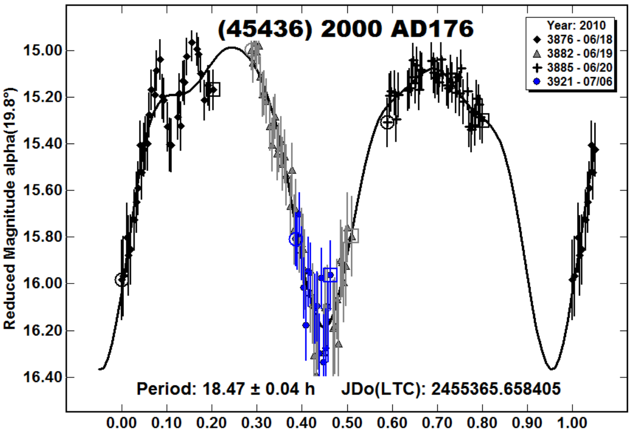

15964 Billgray
Year: 2010
4068 - 09/07
4073 - 09/09
4077 - 09/10
Reduced Magnitude alpha(12.7°)
15.55
15.60
15.65
15.70
15.75
15.80
15.85
15.90
15.95
16.00
16.05
16.10
16.15
Period: 3.571 ± 0.003 h
JDo(LTC): 2455446.602807
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

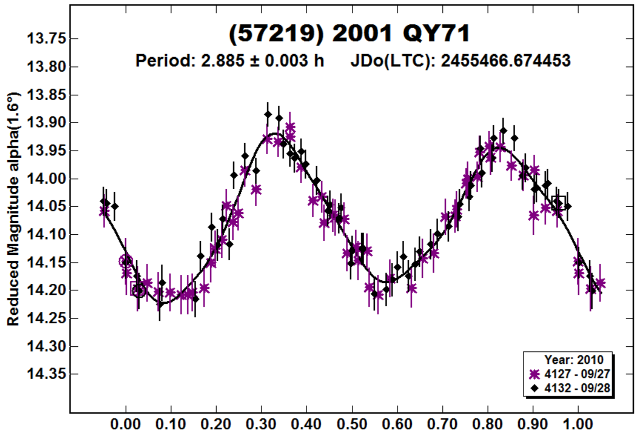

7087 Lewotsky
Period: 5.15 ± 0.01 h
JDo(LTC): 2455423.637661
Reduced Magnitude alpha(22.0°)
14.50
14.55
14.60
14.65
14.70
14.75
14.80
14.85
14.90
14.95
15.00
15.05
15.10
Year: 2010
3968 - 08/15
3971 - 08/18
3974 - 08/21
3978 - 08/26
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

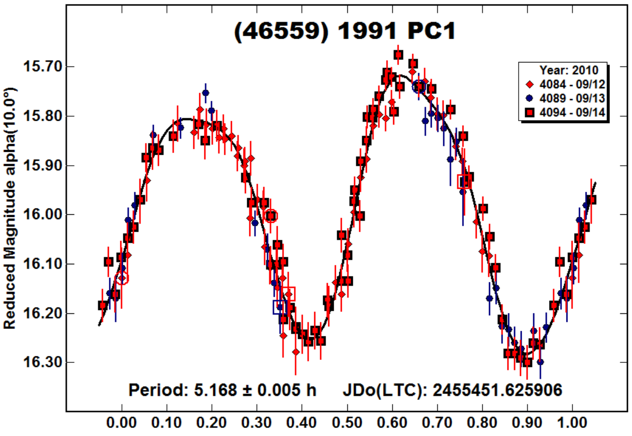

(21688) 1999 RK37
Year: 2010
4017 - 09/03
4039 - 09/04
4042 - 09/05
4081 - 09/11
4122 - 09/26
Reduced Magnitude alpha(29.3°)
14.70
14.80
14.90
15.00
15.10
15.20
15.30
15.40
15.50
Period: 5.6960 ± 0.0005 h
JDo(LTC): 2455442.676237
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

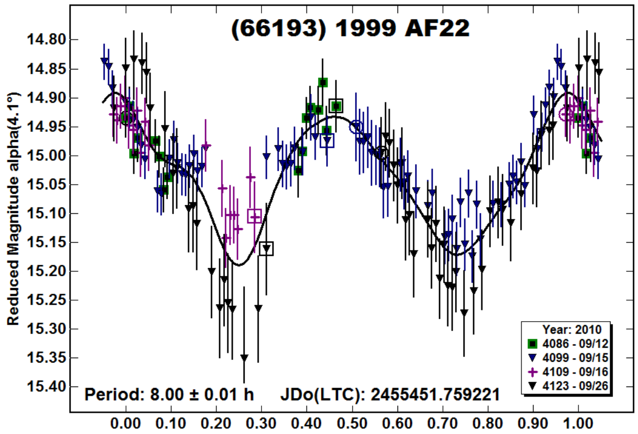

7173 Sepkoski
Period: 2.4996 ± 0.0003 h
JDo(LTC): 2455448.730902
Reduced Magnitude alpha(19.3°)
14.45
14.50
14.55
14.60
14.65
14.70
14.75
14.80
14.85
14.90
14.95
15.00
15.05
Year: 2010
4072 - 09/09
4076 - 09/10
4080 - 09/11
4114 - 09/24
4117 - 09/25
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

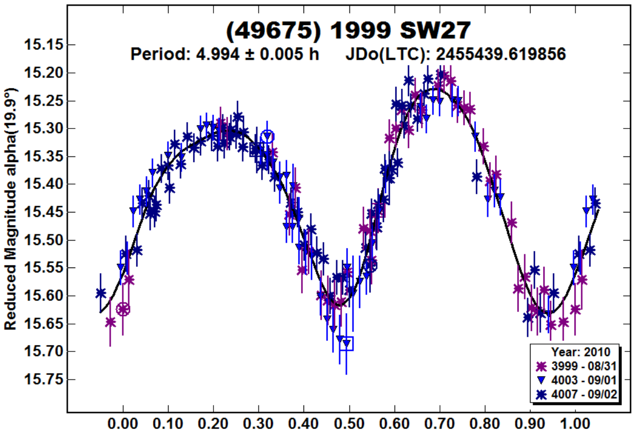

(33203) 1998 FA57
Period: 3.0 ± 0.1 h
JDo(LTC): 2455454.658100
Reduced Magnitude alpha(6.3°)
14.25
14.30
14.35
14.40
14.45
14.50
14.55
14.60
14.65
14.70
14.75
14.80
14.85
Year: 2010
4104 - 09/15
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

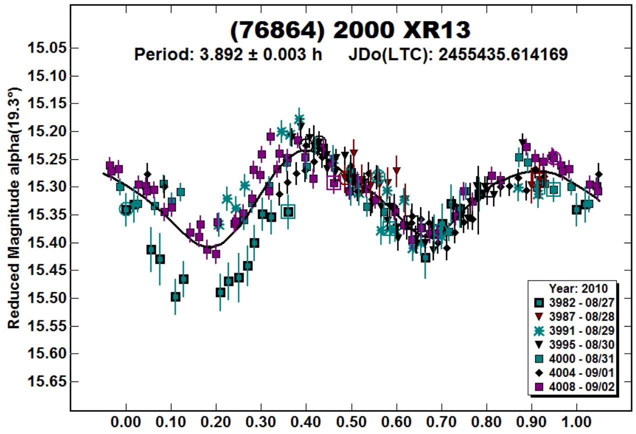

(45436) 2000 AD176
Year: 2010
◆ 3876 - 06/18
▲ 3882 - 06/19
+ 3885 - 06/20
● 3921 - 07/06
Reduced Magnitude alpha(19.8°)
15.00
15.20
15.40
15.60
15.80
16.00
16.20
16.40
Period: 18.47 ± 0.04 h JDo(LTC): 2455365.658405
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

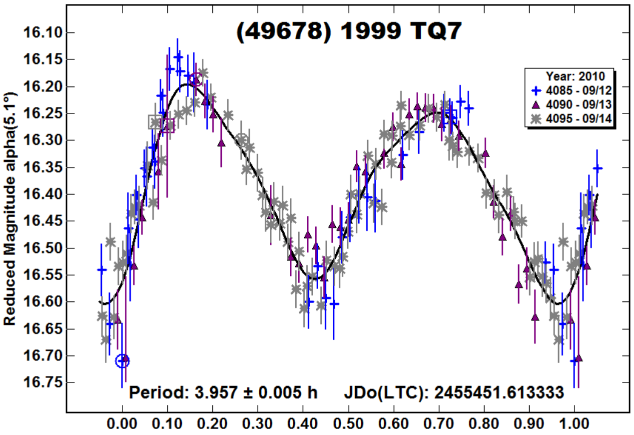

(57219) 2001 QY71
Period: 2.885 ± 0.003 h JDo(LTC): 2455466.674453
Reduced Magnitude alpha(1.6°)
13.75
13.80
13.85
13.90
13.95
14.00
14.05
14.10
14.15
14.20
14.25
14.30
14.35
Year: 2010
✱ 4127 - 09/27
◆ 4132 - 09/28
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

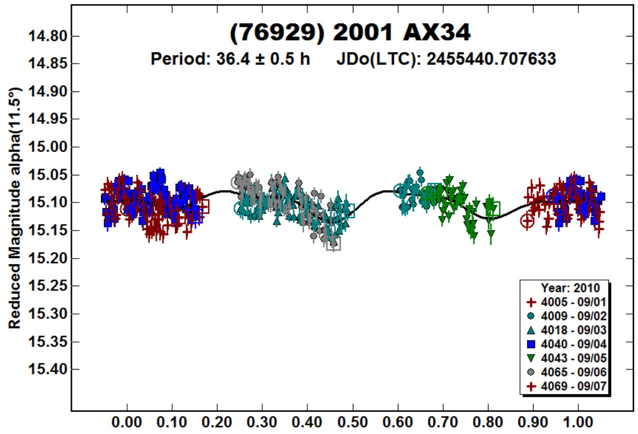

(46559) 1991 PC1
Year: 2010
◆ 4084 - 09/12
● 4089 - 09/13
■ 4094 - 09/14
Reduced Magnitude alpha(10.0°)
15.70
15.80
15.90
16.00
16.10
16.20
16.30
Period: 5.168 ± 0.005 h JDo(LTC): 2455451.625906
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

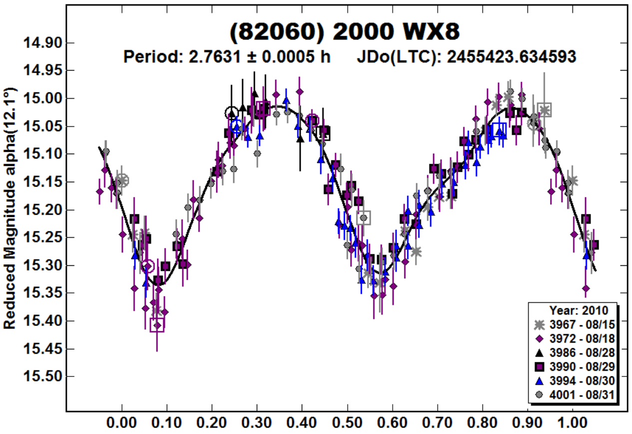

(66193) 1999 AF22
Reduced Magnitude alpha(4.1°)
14.80
14.85
14.90
14.95
15.00
15.05
15.10
15.15
15.20
15.25
15.30
15.35
15.40
Year: 2010
■ 4086 - 09/12
▼ 4099 - 09/15
+ 4109 - 09/16
▼ 4123 - 09/26
Period: 8.00 ± 0.01 h JDo(LTC): 2455451.759221
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

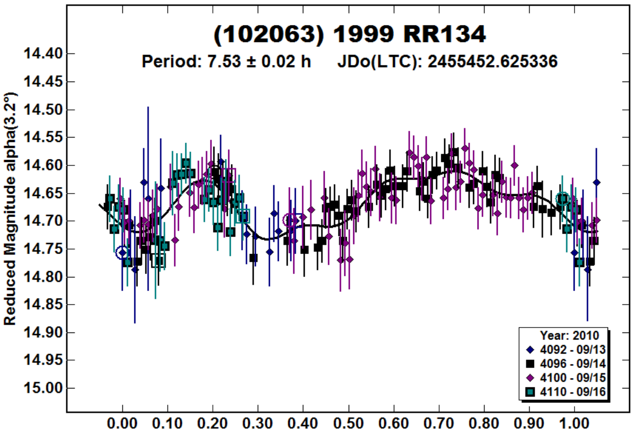

(49675) 1999 SW27
Period: 4.994 ± 0.005 h JDo(LTC): 2455439.619856
Reduced Magnitude alpha(19.9°)
15.15
15.20
15.25
15.30
15.35
15.40
15.45
15.50
15.55
15.60
15.65
15.70
15.75
Year: 2010
✱ 3999 - 08/31
▼ 4003 - 09/01
✱ 4007 - 09/02
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

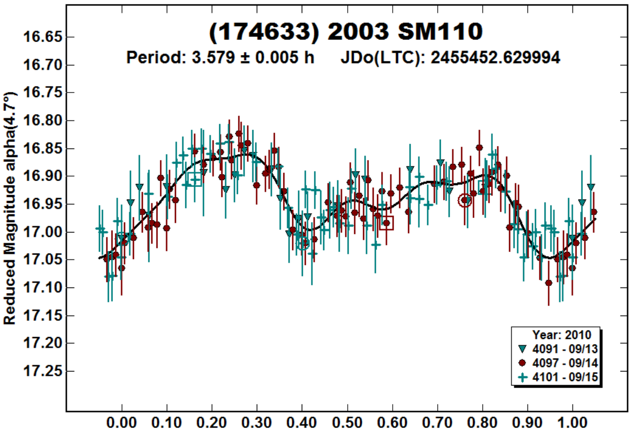

(76864) 2000 XR13
Period: 3.892 ± 0.003 h JDo(LTC): 2455435.614169
Reduced Magnitude alpha(19.3°)
15.05
15.10
15.15
15.20
15.25
15.30
15.35
15.40
15.45
15.50
15.55
15.60
15.65
Year: 2010
■ 3982 - 08/27
▼ 3987 - 08/28
✱ 3991 - 08/29
▼ 3995 - 08/30
■ 4000 - 08/31
◆ 4004 - 09/01
■ 4008 - 09/02
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

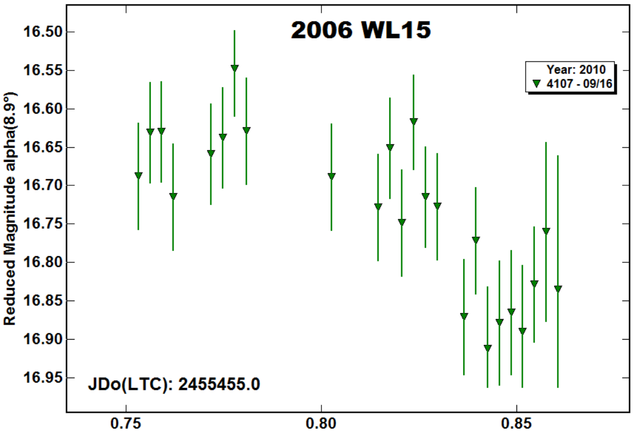

(49678) 1999 TQ7
Year: 2010
+ 4085 - 09/12
▲ 4090 - 09/13
✱ 4095 - 09/14
Reduced Magnitude alpha(5.1°)
16.10
16.15
16.20
16.25
16.30
16.35
16.40
16.45
16.50
16.55
16.60
16.65
16.70
16.75
Period: 3.957 ± 0.005 h JDo(LTC): 2455451.613333
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


(76929) 2001 AX34
Period: 36.4 ± 0.5 h JDo(LTC): 2455440.707633
Reduced Magnitude alpha(11.5°)
14.80
14.85
14.90
14.95
15.00
15.05
15.10
15.15
15.20
15.25
15.30
15.35
15.40
Year: 2010
+ 4005 - 09/01
● 4009 - 09/02
▲ 4018 - 09/03
■ 4040 - 09/04
▼ 4043 - 09/05
● 4065 - 09/06
+ 4069 - 09/07
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00









LIGHTCURVE ANALYSIS OF 1469 LINZIA

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

Vladimir Benishek
Belgrade Astronomical Observatory
Volgina 7, 11060 Belgrade 38, SERBIA

(Received: 30 September)

Observations of the main-belt asteroid 1469 Linzia at Santana Observatory and Belgrade Astronomical Observatory in 2010 September found a synodic period of 22.215 ± 0.004 h and an amplitude of 0.09 ± 0.02 mag.

Benishek made initial observations of the main-belt asteroid 1469 Linzia at Belgrade Astronomical Observatory. See Benishek (2010) for a general description of Belgrade equipment and analysis methods. Because of poor weather, a request was made to Stephens at Santana Observatory to obtain observations to complete the lightcurve. See Stephens (2010) for a general description of equipment at Santana. Night-to-night calibration of the Santana data (generally < ±0.05 mag) was done using field stars converted to approximate Cousins R magnitudes based on 2MASS J-K colors (Warner, 2007; Stephens, 2008).

Behrend (2010) reported a single night of observations from 2004 February resulting in a partial lightcurve and a period of approximately 24 h. Blanco (2000) obtained three nights of sparse data in 1994 resulting in a partial lightcurve with a period of 6.067 h. Our data set of 1,639 data points could not be fit to that result. Because Belgrade and Santana are separated by 137 degrees of longitude, we were able to obtain extended runs on two different nights that covered more than half of our derived period. The final analysis of the lightcurve determined a synodic period of 22.215 ± 0.004 h and amplitude of 0.09 ± 0.02 mag.

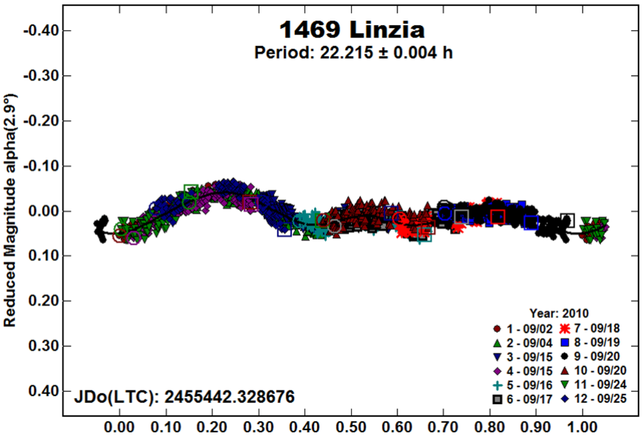


Figure 1. Lightcurve of 1469 Linzia. α = 4.4° to 2.6°, L_{PAB} = 348°, B_{PAB} = 6°.

References

Benishek, V. and Pilcher, F. (2010). "Rotational Period Determination for 2375 Radek." *Minor Planet Bulletin* **37**, 166.

Behrend, R. (2010). Observatoire de Geneve web site, *http://obswww.unige.ch/~behrend/page_cou.html.*

Blanco, C., Di Martino, M., and Riccioli, D., (2000). "New rotational periods of 18 asteroids." *Planetary and Space Science* **48**, 271-284.

Stephens, R.D. (2008). "Long Period Asteroids Observed from GMARS and Santana Observatories." *Minor Planet Bulletin* **37**, 31-32.

Stephens, R.D. (2010). "Asteroids Observed from GMARS and Santana Observatories: 2010 July-September." *Minor Planet Bulletin* **37**, 159-161.

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

ROTATION PERIOD DETERMINATION FOR 103 HERA

Frederick Pilcher
4438 Organ Mesa Loop
Las Cruces, NM 88001-8403 USA
pilcher@ic.edu

David Higgins
Hunters Hill Observatory
7 Mawalan Street
Ngunnawal AC 2913 AUSTRALIA

(Received: 1 October)

For 103 Hera a synodic rotation period of 23.740 ± 0.001 hours and maximum amplitude 0.45 ± 0.03 mag have been found, confirming previous results.

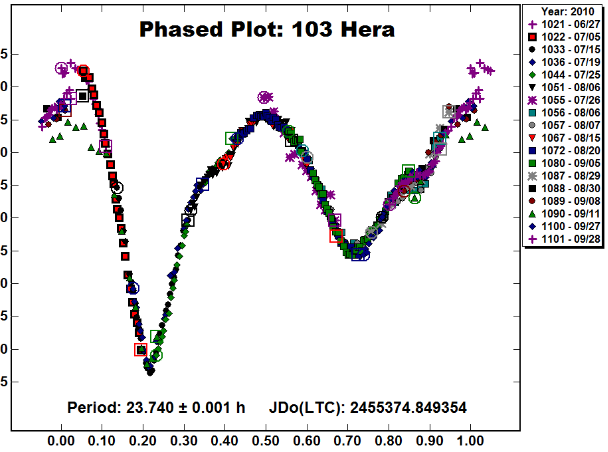
The only previous period determination for 103 Hera is by Harris and Young (1983) who found a period of 23.74 hours, amplitude 0.35 mag near longitude 355 degrees. Because of the very near commensurability with Earth's rotation period, observations over more than 3 months 1979 Aug. 29 – Dec. 10 still covered only 75% of the lightcurve. Earlier observations by Harris and Young (1979) in the year 1978 at longitude 226 degrees, latitude +8 degrees, show only irregular variation of 0.05 mag or smaller with no period determination.

For an object with a rotation period this close to Earth's period observations from widely separated longitudes are required to sample the complete lightcurve at a single apparition. Authors Pilcher and Higgins agreed to collaborate to make these observations. Pilcher at the Organ Mesa Observatory used a 35 cm Meade LX200 GPS S-C, SBIG STL-1001E CCD, R filter, 30-45 s exposures, unguided, instrumental magnitudes only. Higgins at Hunters Hill Observatory also used a 35 cm Meade LX200 GPS S-C, SBIG ST-8 CCD, R filter. Image measurement, lightcurve analysis, and data sharing were done with *MPO Canopus* software. Observations made on 18 nights 2010 June 27-Sept. 28 show a rotation period of 23.740 ± 0.001 hours and bimodal lightcurve with one minimum much deeper than the other one. To make the lightcurve more legible the large number of data points have been binned in sets of 5 with maximum time difference 10 minutes between points. The maximum amplitude defined by this deep minimum was 0.45 ± 0.03 mag June 27 – July 19 at phase angle 23 – 19 degrees and 0.35 ± 0.03 mag when next sampled Aug. 30 – Sept. 11 at phase angles less than 4 degrees. This decrease of amplitude with decreasing phase angle is expected as a consequence of decreased shadowing as observed from Earth. The new data provide multiple full coverage of the lightcurve with results that agree with those of Harris and Young (1983).

References

Harris, A. W. and Young, J. (1979). "Photometric Lightcurves of Asteroids 42 Isis, 45 Eugenia, 56 Melete, 103 Hera, 532 Herculina, and 558 Carmen." *Icarus* **38**, 100-105.

Harris, A. W. and Young, J. W. (1982). "Asteroid Rotation IV. 1979 Observations." *Icarus* **54**, 59-109.



LIGHTUCURVE ANALYSIS OF THE NEAR-EARTH ASTEROID (154029) 2002 CY46

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

Brian A. Skiff, Kyle McLelland
Lowell Observatory
Flagstaff, AZ USA
bas@lowell.edu

(Received: 1 October)

CCD observations of the near-Earth asteroid (154029) 2002 CY46 were made at the Palmer Divide Observatory (PDO) and Lowell Observatory on four nights in 2010 September to support radar observations. The resulting lightcurve parameters found a synodic period of P = 2.554 ± 0.001 h and amplitude of A = 0.07 ± 0.01 mag. No indications of the asteroid being binary were found.

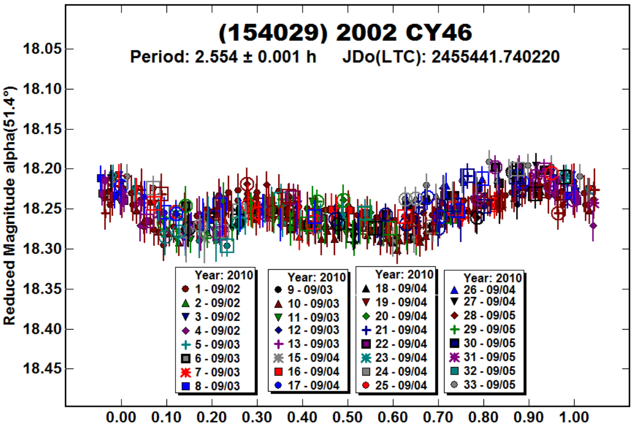
Radar observations in early 2010 September by Howell et al. (private communication) showed the near-Earth asteroid, (154029) 2002 CY46, had a rotation period on the order of 2.5 h. Given the size and rotation period, this meant the chances were good that the asteroid was binary. Lightcurve observations were requested to support the rotation period findings and to look for evidence of a satellite.

CCD observations were obtained on 2010 September 2 through 5 at the Palmer Divide Observatory using a 0.35-m Schmidt-Cassegrain (SCT) with SBIG ST-9XE. Exposures were 60 s and unfiltered. For Lowell, the LONEOS telescope at Anderson Mesa was used on September 2 and 3. The telescope is a 0.55-m f/1.9 Schmidt with a custom-built 2-chip camera with each chip 2Kx4K pixels. For photometry, only 1Kx1K of one chip is used. Exposures were unfiltered and 12 s. Due to the fast sky motion (~5°/day), the observations on a given night had to be separated into several "sessions", where each session used its own set of comparison stars for differential photometry. The sessions were linked to one another using a feature in the *MPO Canopus* software that made use of catalog R (PDO) or Sloan r' (LO) magnitudes for the comparisons. Only solar-colored comparison stars were used in order to minimize color difference errors.

A total of 1855 data points was obtained over the four nights. The lightcurve plot shown here binned the data 5x5, meaning five data points per bin with no data point more than 5 minutes removed from the one before or after it in the unbinned sequence. No individual data point was used more than once – we did not use a running average. Initial measurements of the data from PDO on September 2 found some indications of a satellite. Follow-up reductions and additional observations dispelled that possibility, leaving only a single synodic period of 2.554 ± 0.001 h. The amplitude of the lightcurve was 0.07 ± 0.01 mag.

Acknowledgements

Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNX10AL35G, by National Science Foundation grant AST-1032896, and by a 2007 Gene Shoemaker NEO Grant from the Planetary Society. The observations at Lowell were supported by NASA grant NNX08AR28G.



A QUARTET OF KNOWN AND SUSPECTED HUNGARIA BINARY ASTEROIDS

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

(Received: 2 October Revised: 17 November)

CCD observations at the Palmer Divide Observatory (PDO) were made of four Hungaria asteroids in mid-2010. One of them, 2577 Litva, was a known binary and 2074 Shoemaker was a strong suspect based on earlier observations. (8026) 1991 JA shows indications of being the second member of a suspected new type of binary asteroid characterized by a short period, low amplitude period superimposed on a very long period, high amplitude curve. The fourth object, 20037 Duke, showed no obvious mutual events to indicate a satellite, but shows a weak secondary period of 21.1 h.

Four Hungaria member asteroids were observed at the Palmer Divide Observatory as part of the ongoing study of the group that lies at the inner regions of the main belt (see Warner et al., 2009a, and Milani et al., 2010). During the course of the PDO Hungaria program, more than a dozen binary asteroids have been discovered by lightcurve photometry. In this process, observed deviations from a composite lightcurve are the result of mutual events, occultations and/or eclipses. By subtracting out the lightcurve of the primary body, it is possible to determine the orbital period of the satellite from the remaining data, which show the mutual events. On some occasions, the rotation of the satellite, either fully asynchronous or tidally-locked to its orbit, can also be detected See Pravec et al. (2006) for details on the techniques and analysis of binary lightcurves.

In mid-2010, four Hungarias were observed at PDO. One, 2577 Litva, was a previously-discovered binary (Warner et al., 2009b, 2009c) and was observed to add data for future modeling of the system. Another, 2074 Shoemaker, was a suspected binary following a re-analysis of data taken in 2003 (Stephens, 2004; Warner et al., 2009d). The other two, (8026) 1991 JA1 and 20037 Duke, were new to the PDO program. Each showed signs that they may be binary objects as well.

See the introduction in Warner (2010) for a discussion of equipment, analysis software and methods used and an overview of lightcurve plot scaling. The "Reduced Magnitude" in the plots uses R magnitudes corrected to unity distance by applying –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, e.g., alpha(6.5°), using *G* = 0.15 unless otherwise stated.

Asteroid	Period (hours)			Amplitude (mag)			Ds/Dp
	Primary	Orbital	Secondary	Primary	Events	Secondary	
2074 Shoemaker	2.5338	27.39		0.12	0.15		0.35
2577 Litva	2.81288	35.88	5.6830	0.12	0.10	0.04	0.30
(8026) 1991 JA1	372		2.2981	0.90		0.10	
20037 Duke	5.428	20.21		0.10		0.06	

Table I. A summary of results for four Hungaria asteroids. Ds/Dp is the estimated size ratio of the satellite/primary based on the depth of the mutual events. If a value is missing, it could not be determined from the available data.

2074 Shoemaker. Stephens (2004) observed this asteroid in 2003 and originally reported a period of 57.02 h. The original images were re-measured using current software and calibration techniques (Warner et al., 2009d). As a result, two apparent mutual events were found, indicating a possible binary with an orbital period of 55.5 h. The 2010 campaign was run to see if confirming evidence could be found.

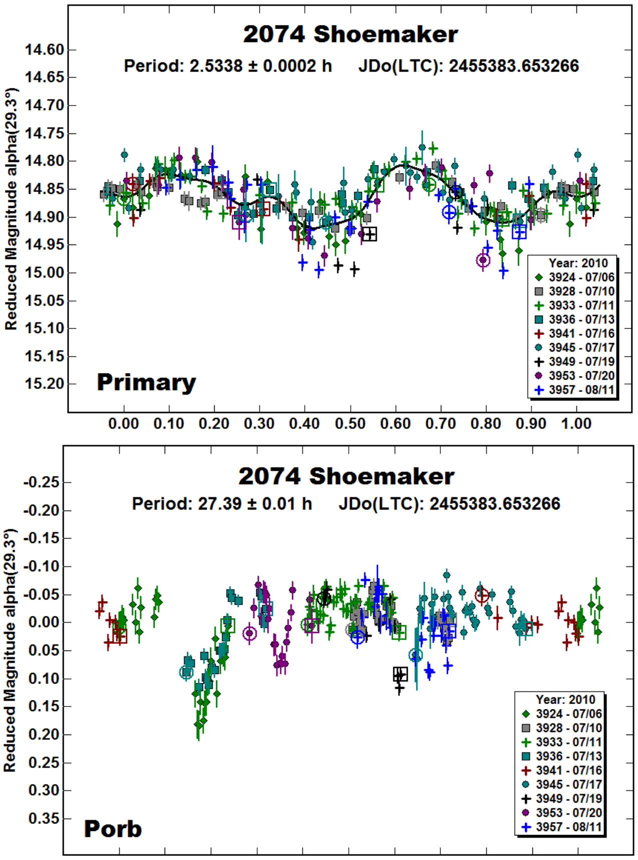


Figure 1. Lightcurves for 2074 Shoemaker.

Assuming the asteroid is binary, the synodic primary period was $P = 2.5338 \pm 0.0002$ h with an amplitude of 0.12 ± 0.01 mag. Only two probable events were seen ($A \sim 0.15$ mag), with incomplete coverage of each. Two, weak events may also have been observed. Assuming the two stronger events were the same event, e.g., an occultation, the orbital period was $P_{orb} = 27.39$ h, or half that found using the data from 2003. A collaboration involving stations well-separated in longitude is needed to establish the asteroid's status with certainty.

2577 Litva. The binary nature of this asteroid was well-established in early 2009 (Warner et al., 2009b, 2009c).

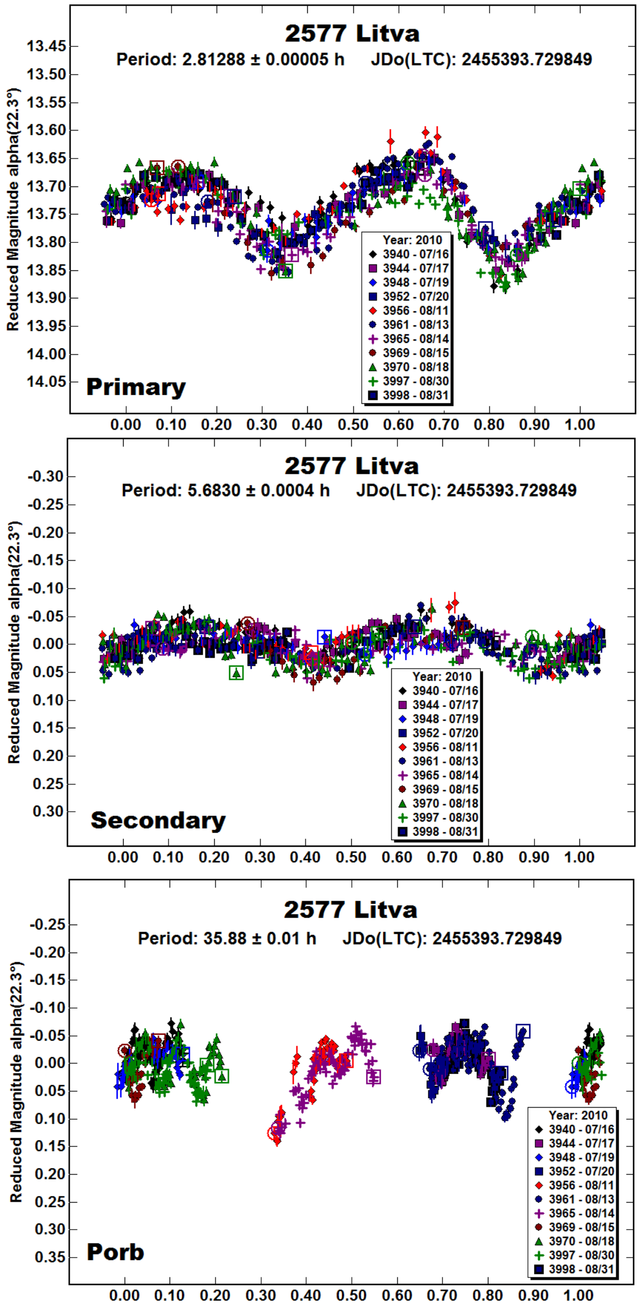


Figure 2. Lightcurves for 2577 Litva. The "Primary" plot did not subtract the "Secondary" period so that the effect of the latter could be seen.

The observations in 2010 at PDO confirmed the earlier results, which show not only the rotation of the primary ($P_1 = 2.81288 \pm 0.00005$ h, $A_1 = 0.12$ mag) and orbital period via mutual events ($P_{orb} = 35.88 \pm 0.01$ h, $A = 0.10$ mag), but a strong secondary period of $P_2 = 5.6830 \pm 0.0004$ h, $A = 0.04$ mag). The interpretation of the second period is that it is the result of the satellite not being tidally-locked to its orbital period. The shape and amplitude of the 2010 lightcurves are different from 2009, which will help with future modeling of the system

(8026) 1991 JA1. This asteroid may be the second member of an unusual type of binary asteroid that shows a short period, low amplitude component superimposed on a very long, high amplitude component. The first member is thought to be (218144)

2002 RL66 (Warner et al., 2010). For (8026), the long component was $P_{long} = 372 \pm 5$ h, $A_{long} = 0.90$ mag while the short component was $P_{short} = 2.2981 \pm 0.0002$ h, $A_{short} = 0.10$ mag. The amplitude for the short component was nearly 2x greater than for (218144), making its detection more certain. Note that the terms "primary" and "secondary" are not used for these two systems. Until additional data are available, e.g., adaptive optics observations, it is not possible to say with certainty which body is the primary and which is the secondary.

The possible discovery of this unusual type binary should lead to more careful examination of long-period lightcurves. However, the temptation to find a secondary period in the noise within the data should be avoided at all costs. Very few – if any – additional objects will actually be binary and so careful work and analysis leading to "extraordinary evidence" will be required.

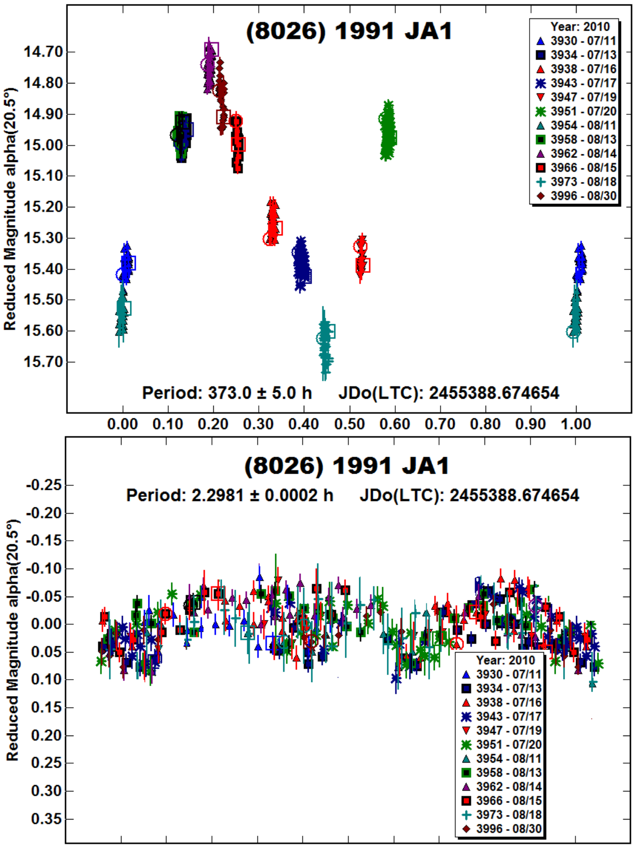


Figure 3. Lightcurves for (8026) 1991 JA1.

20037 Duke. This is the weakest candidate of the quartet presented here. Figure 4 shows the best-fit composite lightcurve assuming a single period of $P = 5.428 \pm 0.001$ h. Using the dual-period analysis tool in the *MPO Canopus* software, a secondary period of 20.21 ± 0.02 h was found. When this period is subtracted from the data, a cleaner "primary" curve with a slightly different period ($P = 5.425 \pm 0.001$ h) results (see figures 5 and 6). The lack of mutual events makes it very difficult to say whether or not the object is a binary. The better result in Figure 5 may be just the result of removing random noise with a pseudo-period of approximately 20 h. On the assumption that it is not, a possible explanation could be the result of a satellite's rotation, likely tidally-locked to its orbit, but with its orbit alignment such that we do not see mutual events. Follow-up campaigns at future apparitions, with high-precision data, should be aware of the possibilities but make no assumptions either way.

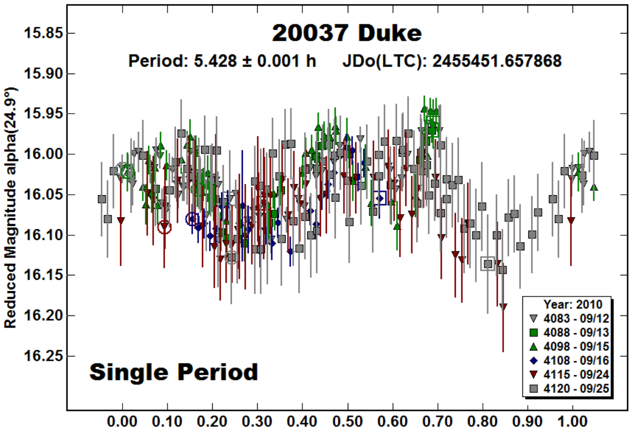


Figure 4. Composite lightcurve of 20037 Duke assuming a single period.

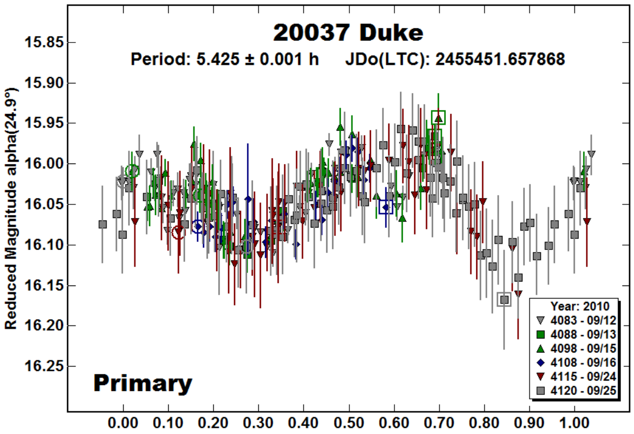


Figure 5. The lightcurve of 20037 with a long period removed.

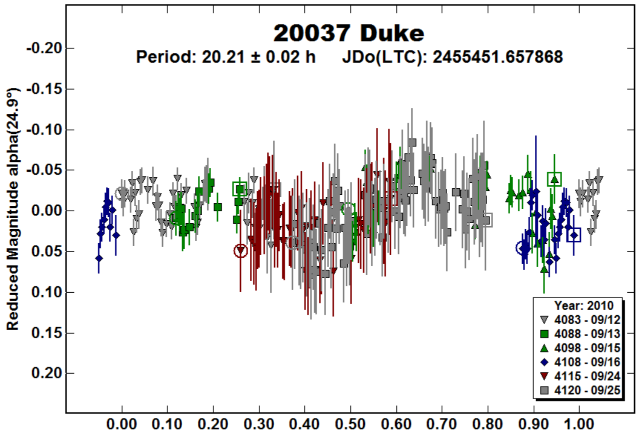


Figure 6. A possible long-period component for 20037.

Acknowledgements

Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNX10AL35G, by National Science Foundation grant AST-1032896, and by a 2007 Gene Shoemaker NEO Grant from the Planetary Society.

References

Milani, A., Knežević, Z., Novaković, B., and Cellino, A. (2010). "Dynamics of the Hungaria asteroids." *Icarus* **207**, 769-794.

Pravec, P., Scheirich, P., Kušnirak, P., Šarounová, L., Mottola, S., and 52 colleagues (2006). "Photometric survey of binary near-Earth asteroids." *Icarus* **181**, 63-93.

Stephens, R.D. (2004). "Photometry of 804 Hispania, 899 Jokaste, 1306 Scythia, and 2074 Shoemaker." *Minor Planet Bul.* **31**, 40-41.

Warner, B.D., Harris, A.W., Vokrouhlický, D., Nesvorný, D., and Bottke, W.F. (2009a). "Analysis of the Hungaria asteroid population." *Icarus* **204**, 172-182.

Warner, B.D., Pravec, P., Harris, A.W., Higgins, D., Bembrick, C., and Brinsfield, J. (2009b). CBET 1715.

Warner, B.D., Pravec, P., Harris, A.W., Higgins, D., Bembrick, C., Brinsfield, J.W., Pray, D.P., Pollock, J., Reichart, D., Ivarsen, K., Haislip, J., LaCluyze, A., and Galad, A. (2009c). "2577 Litva: A Hungaria Binary." *Minor Planet Bul.* **36**, 165-166.

Warner, B.D., Stephens, R.D., Harris, A.W., and Pravec, P. (2009d). "A Re-examination of the Lightcurves for Seven Hungaria Asteroids." *Minor Planet Bul.* **36**, 176-178.

Warner, B.D. (2010). "Asteroid Lightcurve Analysis at the Palmer Divide Observatory: 2009 June-September." *Minor Planet Bul.* **37**, 24-27.

Warner, B.D., Pravec, P., Kušnirak, P., and Harris, A.W. (2010). "A Tale of Two Asteroids: (35055) 1984 RB and (218144) 2002 RL66." *Minor Planet Bul.* **37**, 109-111.

LIGHTCURVES FOR SIX CLOSE APPROACH ASTEROIDS

Peter Birtwhistle
Great Shefford Observatory
Phlox Cottage, Wantage Road
Great Shefford, Berkshire, RG17 7DA
United Kingdom
peter@birtwhi.demon.co.uk

Joseph Masiero
Jet Propulsion Laboratory/California Institute of Technology
Pasadena, CA, USA

(Received: 9 October)

Lightcurves for six very small near-Earth asteroids observed from Great Shefford Observatory during close approaches between 2009 March and 2010 April are reported: 2009 EW, 2009 QH34, 2009 UD, 2009 WV51, 2010 EX11, and 2010 GF7. 2010 EX11 was also observed by Masiero and may be a non-principal axis rotator with periods of 2.7 minutes and ~9 hours.

Photometric observations of six newly discovered near-Earth asteroids during close approaches to Earth were made at Great Shefford Observatory between 2009 March and 2010 April using a 0.40-m Schmidt-Cassegrain and Apogee Alta U47+ CCD camera. All observations were made unfiltered and with the telescope operating at f/6 with a focal reducer. The 1Kx1K, 13-micron CCD was binned 2x2, resulting in an image scale of 2.16 arc seconds/pixel. *MPO Canopus* (Warner, 2008), incorporating the Fourier algorithm developed by Harris (Harris *et al.*, 1989) was used for image measurement using differential aperture photometry and for lightcurve analysis. All lightcurve plots are "phased" according to the period values given in Table I below. Frequent repositioning of the telescope was required due to the fast apparent motion of the objects and, where possible, sets of measurements of adjacent fields were "joined" by measuring overlapping areas. Where this was not possible, small adjustments to the zero points of the comparison star sets for some fields have been made to reduce the RMS of the fitted lightcurves to a minimum. The largest of the objects (2010 EX11) has H = 24.2 (MPCORB), corresponding to a diameter in the range of 30 to 95 meters (Chesley *et al.*, 2002), and all six objects have rotation periods <5 minutes, well within the expected boundaries for monolithic fast rotators. Generally, the fast rotation periods resulted in at least two complete rotations (17 for 2009 UD) being captured during the passage of each object through individual fields of view before telescope repositioning was necessary. 2009 EW was the exception due to its very fast apparent motion with only about 1/3 of its 3.8 min rotation period captured in each telescope field. A search of the Asteroid Lightcurve Database (LCDB, Warner *et al.*, 2010) does not reveal any previously reported results other than for 2010 EX11.

2009 EW. The asteroid was observed briefly on 2009 March 4 and then for 5 h 26 min on 2009 March 5 when it reached 16th magnitude during an approach to within 350,000 km of Earth. At its closest, the movement against the sky of more than 430"/min forced integrations to be as short as 0.4 seconds to stop the minor planet trailing during exposures.

2009 QH34. This object was followed for 4.2 h during the first night of observation and then for a further 3.4 h on the following night; it was 16th magnitude on both nights. Independent determinations of the rotation period from the two nights result in 1 S.D. errors of <7% of one rotation when extrapolated from one set to the other, allowing the two nights to be unambiguously combined for the final period reduction.

2009 UD. Observed for 2.1 h in the early morning of 2009 Oct. 17 and then for a further 3.2 h the following evening, 2009 UD was 17th magnitude on both nights. Exposures were limited to 10 s and 8 s due to the moderately fast apparent motion. The longer exposure length represents about 12% of the very short derived rotation period of 83.7 s (see Table II). According to Pravec *et al.* (2000) this results in smearing of features smaller than about 20% of the period when employing a third-order Fourier fit, as was used for the lightcurve. 2009 UD completed 1080 rotations during the 25-hour span of observations.

2009 WV51. Another 17th mag object, this asteroid was observed over a period of 3.5 hours during a close approach of 0.006 AU to Earth, during which time it completed 45 rotations.

2010 EX11. The asteroid was observed from Great Shefford on 2010 March 15 for 6 h 45 min and again on March 21 for 2 h 46 min. A further 4 h 54 min of observations were obtained on March 22. 2010 EX11 brightened from magnitude +18.8 on March 15 to +17.6 on March 22 and, although the curves are noisy, an unambiguous rotation period was derived independently for each of the three nights: 160.32 s, 160.39 s and 160.28 s from March 15,

Name	Date range yyyy mm/dd	Phase (deg)	PAB_L (deg)	PAB_B (deg)	Period (h)	PE	Amp. (mag)	AE
2009 EW	2009 03/04-03/05	37.7-96.0	144.8	28.2	0.06363	0.00001	1.5	0.2
2009 QH34	2009 08/28-08/29	26.0-20.9-21.1	334.0	10.9	0.034303	0.000001	0.5	0.1
2009 UD	2009 10/17-10/18	8.7-9.5	28.9	-1.8	0.023246	0.000001	0.66	0.15
2009 WV51	2009 11/23	13.4-12.2	65.1	-5.6	0.07660	0.00006	0.9	0.2
2010 EX11	2010 03/15-03/23	54.7-22.0	175.5	25.4	0.0445307	0.0000006	0.3	0.1
2010 EX11	2010 03/19-03/20	31.7	174.7	16.0	9.4	0.1	0.32	0.02
2010 GF7	2010 04/08	61.8-63.9	203.0	31.6	0.03181	0.00002	0.8	0.2

Table I. Observing circumstances, including observation dates, phase angle range, average phase angle bisector longitude and latitude, derived synodic rotation period with error estimate and lightcurve amplitude with error estimate.

Name	Station	Data points	Exposure (s)	Exposure / Period	H	Est. Size (m)
2009 EW	GSO	310	4,1,0.4	0.004	26.4	16
2009 QH34	GSO	1024	6,4	0.049	24.9	33
2009 UD	GSO	511	10,8	0.119	27.2	11
2009 WV51	GSO	261	8	0.029	27.1	12
2010 EX11	GSO	1448	10,6	0.037	24.2	45
2010 EX11	TMO	45	600	0.017		
2010 GF7	GSO	580	2	0.017	25.9	21

Table II. Ancillary details, including the observing station (GSO=Great Shefford Observatory, TMO=Table Mountain Observatory), number of data points used in analysis, exposure lengths, the primary exposure length as a fraction of the rotation period, the Absolute Magnitude (from the MPC database) with associated size estimate assuming albedo for S-type minor planets.

21, and 22 respectively. Figure 1 represents period spectrum plots from the three nights with RMS values arbitrarily adjusted to space the three solutions apart for clarity and show RMS minima at 0.022 h, 0.045 h and 0.067 h on each night, equating to monomodal, bimodal and trimodal solutions, the bimodal value being assumed here to be correct.

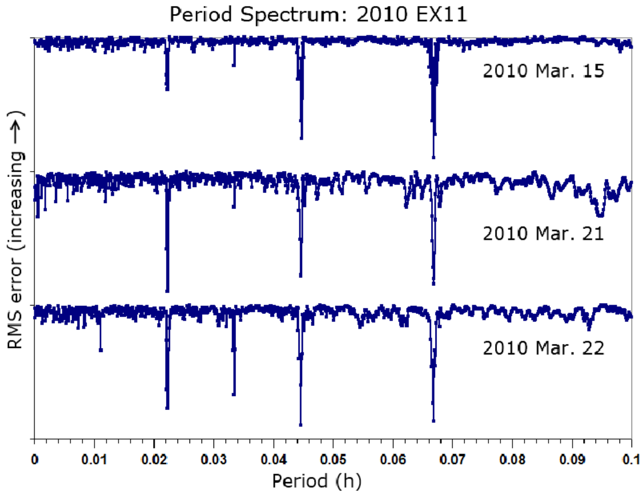


Figure 1. Independent period spectrum determinations from three nights of data from Great Shefford.

The 1 S.D. error in the period derived from the March 22 observations, extrapolated back to March 21, was 14% of one rotation, allowing the rotations from March 21 and 22 to be matched. The 1 S.D. error in the period derived from the combined March 21 and 22 data, extrapolated back to March 15, was 9% of one period and again allowed matching with the already tightly constrained period derived from March 15 data alone. 2010 EX11 completed 3864 rotations during the 7.17 day span of observations. Masiero (2010) gives a partial lightcurve from observations obtained using the 0.6-m telescope at the Table Mountain Observatory (TMO), Wrightwood, CA, USA. These were made on 2010 March 20 over a period of 6h 40 min. However, with individual exposures of 10 minutes, any verification of the short 2.7 minute rotation period determined from Great Shefford is ruled out. The Masiero lightcurve consists of 35 data points with error bars set at ±0.02 mags and shows probably two maxima and one, possibly two minima, with an amplitude of ~0.25 mag. Ten previously unpublished data points were also obtained on 2010 March 19 from TMO. The results from the two nights have been combined by Birtwhistle and support periods of 9.4 ±0.1 h and 14.2 ±0.5 h almost equally well, with a phased plot of the former being given below. A weaker solution at 7.0 h appears much less satisfactory. The Great Shefford data have been searched for evidence of a longer period but, although variation of up to 0.3 magnitudes may be present over a timescale of several hours and also between nights, the scatter in the data precludes any safe conclusions being drawn.

2010 GF7. The asteroid was followed for 1 h 56 min on 2010 April 8 when it reached its peak magnitude of ≈ +17.6 during an approach to within 0.008 AU of Earth. The object was well placed, within 13° of the zenith throughout the observing period, and motion was 76”/min, which necessitated limiting exposures to 2 s. Although the lightcurve is again noisy, a period spectrum (Figure 2) shows sharp RMS minima at 0.0159 h, 0.0318 h and 0.0477 h, corresponding to monomodal, bimodal and trimodal solutions. There were no other minima from 0.2-2.0 h. 2010 GF7 completed 60 revolutions during the period of observation.

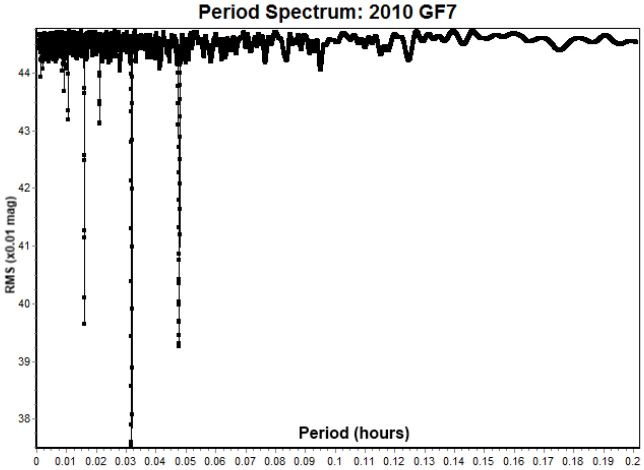


Figure 2. Period spectrum for 2010 GF7

References

Chesley, S.R., Chodas, P.W., Milani, A., and Valsecchi, G.B. (2002). "Quantifying the risk posed by potential Earth impacts." *Icarus* **159**, 423-432.

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

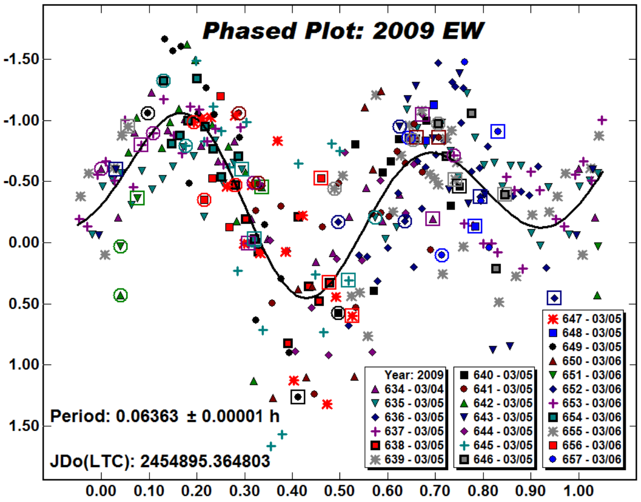
Masiero, J. (2010). *http://astrojoesbarandgrill.com/Asteroids/EX11/*

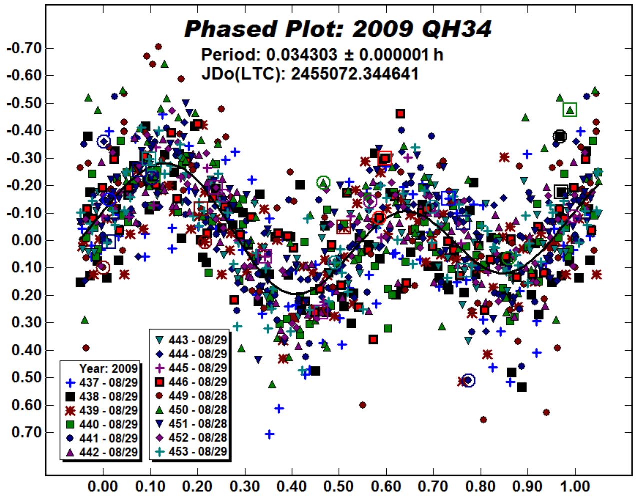
Minor Planet Center Orbit Database (MPCORB) *http://www.minorplanetcenter.org/iau/MPCORB.html*

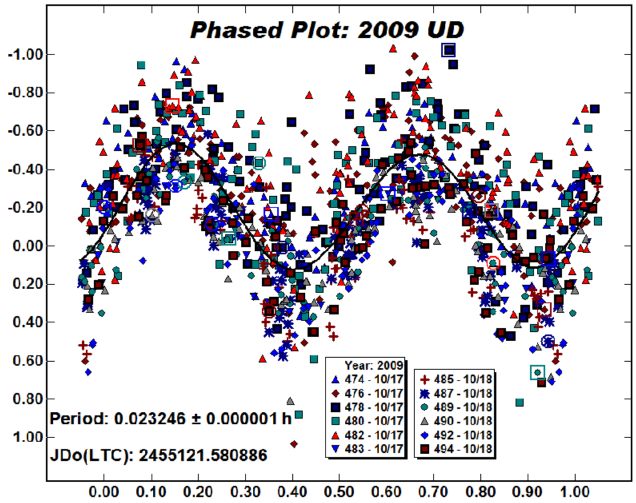
Pravec P., Hergenrother C., Whiteley R., Sarounova L., Kusnirak P., and Wolf M. (2000). "Fast Rotating Asteroids 1999 TY2, 1999 SF10, and 1998 WB2." *Icarus* **147**, 477-486.

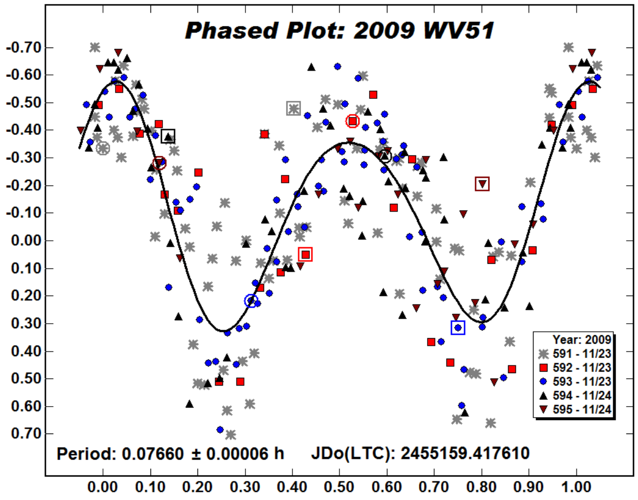
Warner, B.D. (2008). MPO Software, *MPO Canopus* version 9.5.0.3, Bdw Publishing, Colorado Springs, CO.

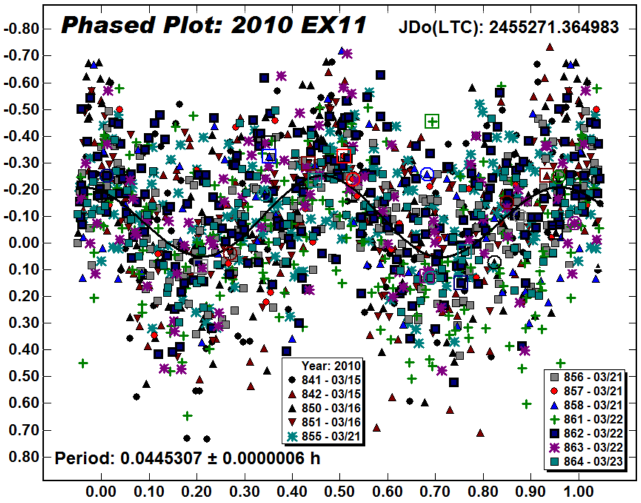
Warner, B.D., Harris, A.W., and Pravec, P. (2010). "Asteroid Lightcurve Data File, Revised May. 21, 2010." *http://www.MinorPlanetObserver.com/astlc/default.htm.*

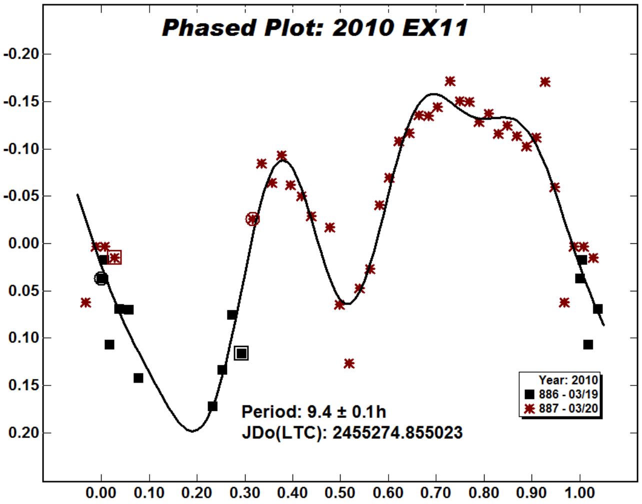


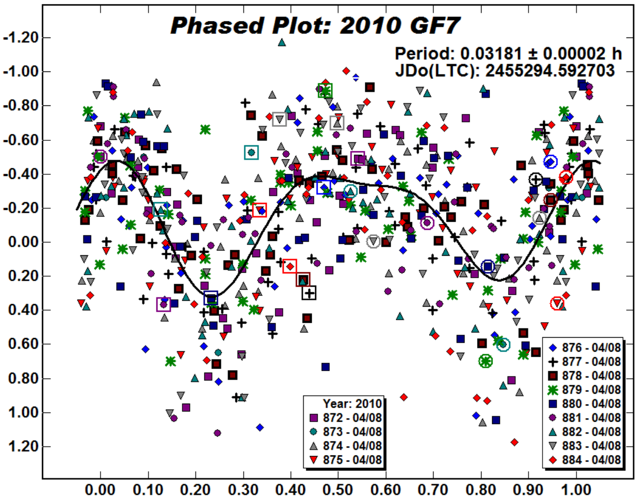












ASTEROIDS OBSERVED FROM THE SHED OF SCIENCE OBSERVATORY: 2010 MAY-OCTOBER

Russell I. Durkee
Shed of Science Observatory
Minneapolis, MN, 55410, USA
shedofscience@earthlink.net

(Received: 11 October)

Lightcurve measurements from the Shed of Science Observatory from 2010 May to October are reported: 1142 Aetolia, P = 10.730 ± 0.005 h, A = 0.18 ± 0.03 mag; 1521 Seinajoki, P = 4.32 ± 0.01 h, A = 0.14 ± 0.04 mag; 1643 Brown, P = 5.932 ± 0.006 h, A = 0.49 ± 0.03 mag; 1996 Adams, P = 3.311 ± 0.002 h, A = 0.42 ± 0.04 mag; 14790 Beletskij, P = 3.146 ± 0.002 h, A = 0.29 ± 0.04 mag.

Lightcurves of five asteroids were completed between 2010 May and October at the Shed of Science Observatory. A 0.35-m Schmidt Cassegrain (SCT) was used with an SBIG ST-10XE 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.

1142 Aetolia. The result of $P = 10.730 \pm 0.005$ h agrees well with the period reported by Behrend (2010). The measured amplitude was $A = 0.18 \pm 0.03$ mag.

1521 Seinajoki. A period of $P = 4.32 \pm 0.01$ h with $A = 0.14 \pm 0.04$ mag was determined. No previously reported period could be found.

1643 Brown. Analysis found parameters of $P = 5.932 \pm 0.006$ h, $A = 0.49 \pm 0.03$ mag. No previously reported period could be found.

1996 Adams. The result of $P = 3.311 \pm 0.002$ h differs from earlier results by Alvarez-Candal *et al.* (2004), who reported $P = 3.56$ h based on an incomplete lightcurve. Our observations span the entire period on three nights. The new result is in close agreement with the period found by Aymami (this issue, pp. 55-56). The measured amplitude from our data set was 0.42 ± 0.04 mag

14790 Beletskij. A period of $P = 3.146 \pm 0.002$ h with $A = 0.29 \pm 0.04$ mag was determined. No previously reported lightcurve parameters were found.

Acknowledgements

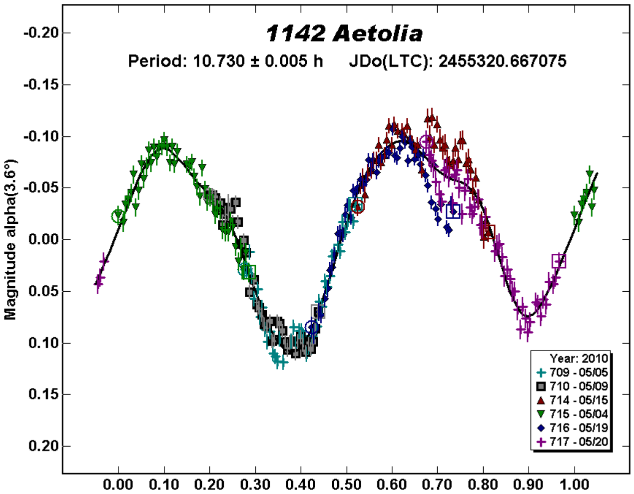
Partial funding for work at the Shed of Science is provided by a 2009 Gene Shoemaker NEO Grant from the Planetary Society.

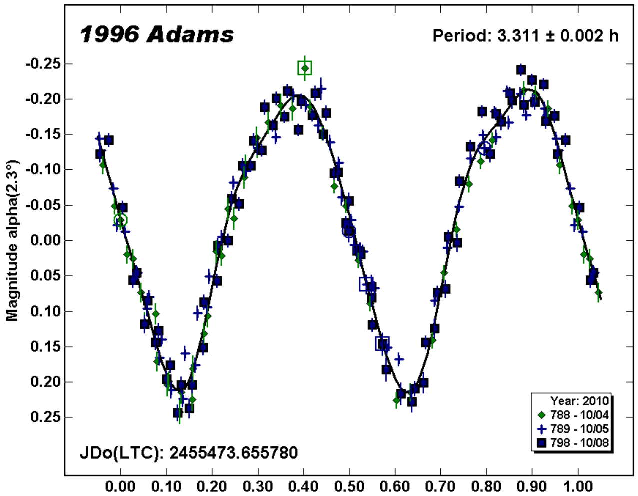
References

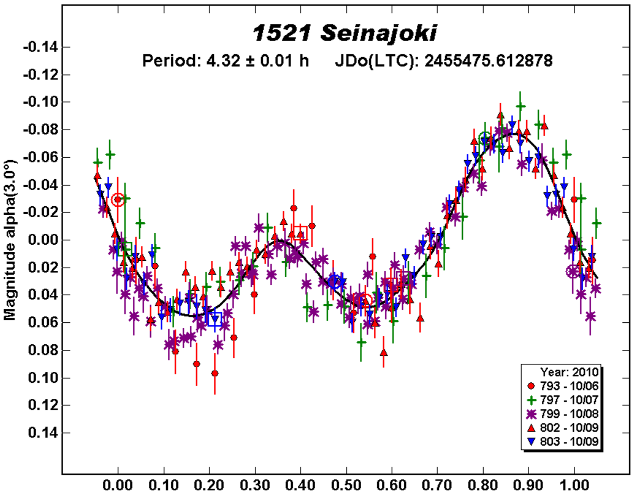
Alvarez-Candal, A., Duffard, R. Angeli, C.A.; Lazzaro, D., and Fernandez, S. (2004). "Rotational lightcurves of asteroids belonging to families." *Icarus* **172**, 388-401.

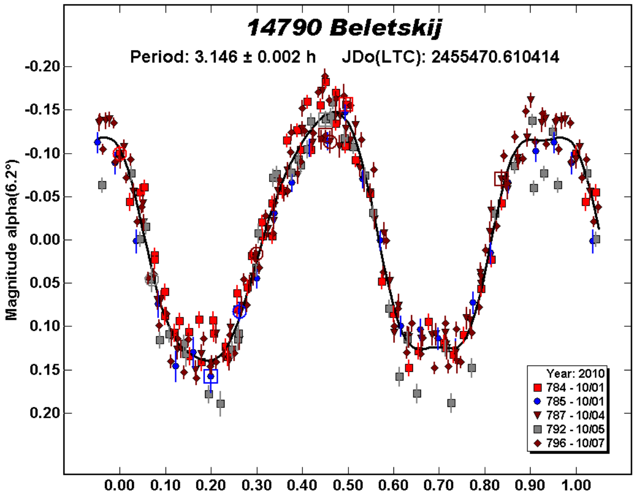
Behrend, R. (2010). Observatoire de Geneve web site, *http://obswww.unige.ch/~behrend/page_cou.html*

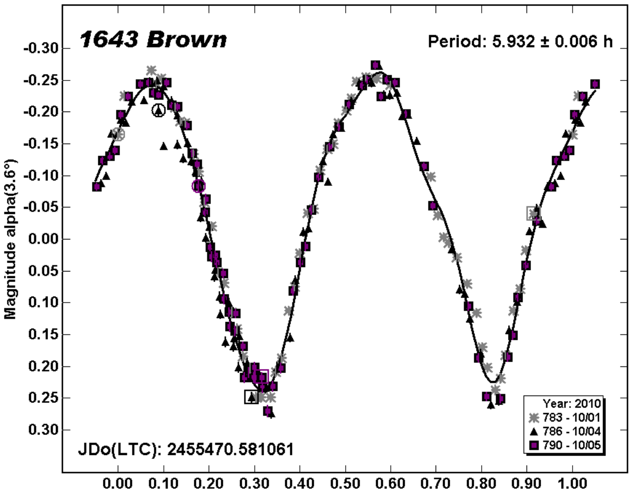
Warner, B.D., Harris, A.W., and Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146.











THE LIGHTCURVE OF ASTEROID 4223 SHIKOKU

Russell I. Durkee
Shed of Science Observatory
5213 Washburn Ave S., Minneapolis, MN 55410 USA
shedofscience@earthlink.net

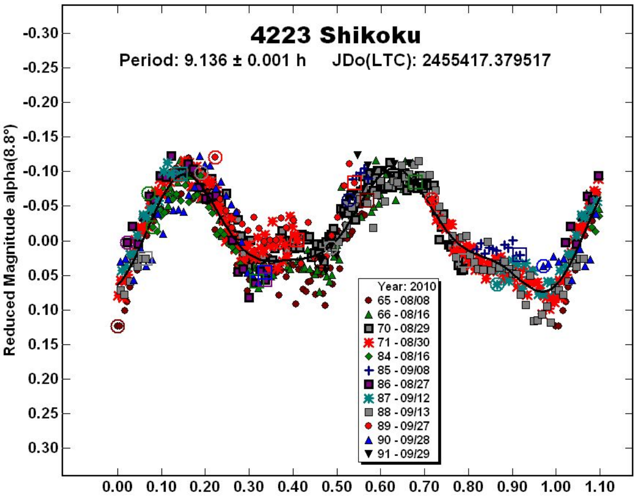
Andrea Ferrero
Bigmuskie Observatory
via Italo Aresca 12, 14047 Mombercelli-Asti, ITALY

(Received: 11 October)

Asteroid 4223 Shikoku was observed on 11 nights in 2010 August and September. A period of P = 9.137 ± 0.002 h with an amplitude of A = 0.17 ± 0.03 mag was derived.

Observations of 4223 Shikoku were carried out over 11 nights at the Shed of Science Observatory and Bigmuskie Observatory in 2010 August and September. Durkee selected the object using the information from the CALL website (Warner, 2010). Our collaboration began when Durkee noticed Ferrero posted his derived period on the CALL site a few weeks later (Ferrero, 2010). Durkee contacted Fererro and suggested merging the two data sets.

Durkee used a 0.35-m f/8.6 Schmidt-Cassegrain with an SBIG ST10XE CCD camera binned 2x2, resulting in an image scale of 0.94 arc seconds per pixel. Durkee's exposures were made through a Celestron UHC filter and were unguided. Ferrero used a 0.3-m f/8 Ritchey-Chretien with an FLI Max Cam CM9 CCD and an image scale of 1.72 arc seconds per pixel. Ferrero's images were unfiltered and unguided. Ferrero observed the object on August 8, 16, 29, and 30. Durkee's observations took place on August 16, 27, September 8, 12, 13, 27, 28, and 29. Both stations used *MPO Canopus* to perform differential photometry on the reduced images.



Acknowledgements

Thanks go to Brian Warner and his CALL website for making this collaboration possible. Partial funding for work at the Shed of Science is provided by a 2009 Gene Shoemaker NEO Grant from the Planetary Society.

References

Ferrero, A. (2010). Lightcurve Results (on CALL web site). *http://www.minorplanetobserver.com/Data/submissions_results.htm*

Warner, B.D. (2010). "Potential Lightcurve Targets 2010 July – September." *http://www.minorplanetobserver.com/astlc/targets_3q_2010.htm*

PERIOD DETERMINATION OF ASTEROID TARGETS OBSERVED AT HUNTERS HILL OBSERVATORY: MAY 2009 - SEPTEMBER 2010

David Higgins
Hunters Hill Observatory
7 Mawalan Street, Ngunnawal, ACT 2913, Australia
higginsdj@bigpond.com

(Received: 11 October Revised: 22 November)

Lightcurves for 27 asteroids were obtained at the Hunters Hill Observatory (HHO) from 2009 May through 2010 September: 308 Polyxo, 326 Tamara, 369 Aeria, 504 Cora, 822 Lalage, 1164 Kobolda, 1619 Ueta, 1625 The NORC, 1685 Toro, 2189 Zaragoza, 2287 Kalmykia, 2639 Planman, 3695 Fiala, 4786 Tatianina, 5333 Kanaya, (5452) 1937 NN, 6170 Levasseur, 7741 Fedoseev, 14815 Rutberg, 15724 Zille, 16525 Shumarinaiko, (21996) 1999 XP31, (29729) 1999 BY1, (35404) 1997 YV5, (39087) 2000 VN50, (66146) 1998 TU3, and (101769) 1999 FF52.

Observations of all minor planets were obtained at Hunters Hill Observatory using a 0.36-m f/4 Meade LX200GPS Schmidt-Cassegrain and SBIG ST-8E CCD camera. Exposures varied according to the brightness of the target; all were guided and taken through a clear filter. Image measurement and lightcurve analysis were undertaken using the latest release or beta version of *MPO Canopus* at the time the target was observed.

308 Polyxo. The period found here agrees well with published periods of 12.032 h and 12.02 h by Warner (2010). Due to its period being commensurate with 24 h, and since no collaborators were available, the lightcurve plot could not be closed.

326 Tamara. Previous observations by Gil-Hutton and Pray (Warner, 2010) indicated periods of 14.184 h and 14.446 h, respectively. The data captured at HHO would not fit the 14.184 h period but did closely fit the period found by Pray. The single night's data that did not appear to fit the curve may well indicate a new maximum, not uncommon for observations taken during large phase angles and taken more than two weeks after the initial data.

369 Aeria. Previous observations by Schober, and Dotto (Warner, 2010) indicated periods of 14.0, 4.82, and 4.787 h. The 299 data points taken at HHO over 8 nights showed only a single fit at 4.7776 ± 0.0002 h with no fit possible at either the 4.787 h or 4.82 h periods. The lightcurve appears to be monomdal in nature. A bimodal curve was fitted to a period of 9.555 ± 0.002 h. Due to the small amount of noise in the data and the low amplitude of the lightcurve, it is not possible to distinguish which period may be correct. The plot is phased to the longer period.

1619 Ueta. Previous observations by Almeida *et al*. (2004) derived a period of 2.94 h from limited data taken on a single night. An additional attempt was undertaken by Addleman *et al*. (2005) but found the amplitude too low to derive a period. The data obtained at HHO uncovered a period of 2.732 h, which is close to the period being reported by Stephens (2010) on the CALL web site.

1685 Toro. This target was observed for a third apparition in support of YORP analysis. The period derived closely agrees with the synodic period derived in previous apparitions (e.g., Higgins, 2008; Higgins *et al.*, 2008b). With so much coverage, this would be an excellent candidate for shape modeling.

2287 Kalmykia. This target was identified for the BINAST survey (Pravec *et al.*, 2006). After two nights of observations, Pravec closed the target and no further observations were undertaken. Although a very loose fit could be found at 12.22 h, this served only to constrain a lower period limit.

2639 Planman. This was another BINAST identified target but rather than close it off due to its obviously long period, observations continued at HHO for as long as possible. The result was a possible monomdal fit at 44.8 h and a bimodal fit at 89.5 h

3695 Fiala. This target turned out to be too faint given its apparent amplitude and so was discontinued. The data did, however, constrain a likely minimum period of 4.1 h.

6170 Levasseur. This asteroid was observed for a second apparition by the BINAST group since it was considered a binary candidate. The first apparition was observed by Pray (Warner, 2010). The HHO data for this apparition, although quite noisy, did fit well with Pray's period of *P* = 2.6529 h. There were unconfirmed indications of a second period of 29-30 hours with unresolved eclipsing events.

15724 Zille. This was a serendipitous target found in the field of view (FOV) of 4029 Bridges on a single night. The images were measured but the target far too faint for adequate follow-up. No period was determined but a lower limit of 5.6 h is plausible.

14815 Rutberg. It became apparent after the first session that this was a long period target. The Comp Star Selector differential photometry process inside *MPO Canopus* was used to link the nightly sessions without relying on manually modifying the nightly zero points. Unfortunately there were just not enough clear nights to complete this target.

16525 Shumarinaiko. This was a serendipitous target found in the FOV of (6265) 1985 TW3 on a single night. The data were measured but the period was unresolved, although it might be constrained to not less than 8.8 h. The data derived for this target did not fit the 2.6425 h period reported by Behrend (Warner, 2010). The target was not followed up.

(21996) 1999 XP31. This was a serendipitous target found in the FOV of 4786 Tatianina on a single night. The data were measured but a period could not determined.

(29729) 1999 BY1. Although a seemingly simple target there were insufficient opportunities to complete this target due to poor weather.

(39087) 2000 VN50. This was a serendipitous target found in the FOV of (35404) 1997 TV5 and found to be just bright enough to follow up.

(66146) 1998 TU3. A recent announcement by Hicks *et al*. (2010) stated that they had uncovered possible evidence of this asteroid being binary. At the recommendation of Brian Warner and Alan Harris (private communications), observations were made of the asteroid during the same apparition to see if confirmation of the binary nature could be found, e.g., mutual events due to occultations and/or eclipses. No deviations were noted and the period found agrees with the period found at HHO during the 2003 apparition (Higgins, 2010) as well as that reported by Galad *et al*. (2005) and Hicks *et al*.

(101769) 1999 FF52. This was a serendipitous target found in the FOV of 3034 Chimenhaga on one night. The images were measured but the target was not followed up. The data constrain a period to not less than 8.6 h.

Number	Name	Dates mm/dd/20	Phase	PAB_L	PAB_B	Period (h)	Amp (mag)
308	Polyxo	06/11-06/12/10	11.5-11.9	234	5	12.01 ± 0.02	0.13 ± 0.01
326	Tamara	05/07-05/27/09	32.4-31.7	302	-27	14.454 ± 0.003	0.27 ± 0.03
369	Aeria	05/10-6/16/09	5.2-15.2	226	11	4.7774 ± 0.0002[1]	0.06 ± 0.01
504	Cora	09/20-09/24/10	5.3	226	12	7.588 ± 0.003	0.20 ± 0.01
822	Lalage	10/19-10/20/09	9.2	10	0	3.3465 ± 0.0006	0.58 ± 0.01
1164	Kobolda	11/08-11/13/09	16.7-17.1	45	-32	4.142 ± 0.001	0.28 ± 0.03
1619	Ueta	09/30-10/01/10	6.4	3.6	-8.1	2.720 ± 0.002	0.35 ± 0.01
1625	The NORC	05/10-05/27/09	10.4-14.3		-20	13.959 ± 0.004	0.16 ± 0.02
1685	Toro	05/08-05/12/10	8.3-9.8	222	-11	10.199 ± 0.003	0.65 ± 0.02
2189	Zaragoza	11/08-11/10/09	13.0-12.4	56	-19	4.934 ± 0.003	0.17 ± 0.02
2287	Kalmykia	04/13-04/21/10	10.5-6.9	220	6	> 12.2[2]	0.07 ± 0.01
2639	Planman	05/01-05/27/09	6.9-11.6	227	7	89.47 ± 0.04	0.40 ± 0.03
3695	Fiala	12/05/09	13.4	55	-10	> 4.1[2]	>0.07
4786	Tatianina	07/08-07/21/10	3.1-4.6	290	1	2.9228 ± 0.0003	0.25 ± 0.02
5333	Kanaya	04/13-05/06/10	9.2-4.6	218	2	3.8024 ± 0.0002	0.15 ± 0.02
5452	1937 NN	07/16-07/21/10	18.8-16.2	321	2	3.2562 ± 0.0003	0.50 ± 0.03
6170	Levasseur	04/08-05/06/10	9.6-10.5	211	-11	2.6528 ± 0.0004	0.13 ± 0.02
7741	Fedoseev	11/13-12/15/09	11.9-16.8	58	-18	14.074 ± 0.004	0.12 ± 0.03
14815	Rutberg	08/08-09/11/10	5.2-23.5	315	4	153.4 ± 0.4	1.0 ± 0.05
15724	Zille	05/19/10	10.0	217	1	> 5.6[2]	0.20 ± 0.05
16525	Shumarinaiko	06/13/10	7.8	249	-3	>8.8[2]	>0.1
21996	1999 XP31	07/21/10	4.1	291	1	>3[2]	>0.4
29729	1999 BY1	01/09/10	5.6	110	-8	4.57 ± 0.02	0.60 ± 0.05
35404	1997 YV5	08/29-09/27/10	8.7-21.9	326	6	5.7457 ± 0.0003	0.35 ± 0.02
39087	2000 VN50	09/26-09/27/10	19.5	328	8	>9[2]	0.55 ± 0.05
66146	1998 TU3	09/18-09/24/10	46.4-41.0	25	-17	2.3774 ± 0.0003	0.07 ± 0.01
101769	1999 FF52	10/20/09	23.9	335	-2	>8.6[2]	0.37 ± 0.05

Table I. Observing circumstances. PAB is the average phase angle bisector longitude (L) and latitude (B) over the range of observations.

1. Ambiguous. P = 9.555 h is possible.
2. Ambiguous. Value is lower limit.

References

Addleman, D., Covele, B., Duncan, A., Johnson, J., Kramb, S., Lecrone, C., Reichert, C., Starnes, H., Twarek, A., Kirkpatrick, E., and Ditteon, R. (2005). "Rose-Hulman spring 2005 lightcurve results: 155 Scylla, 590 Tomyris, 1655 Comas Solá, 2058 Roka, 6379 Vrba, and (25934) 2001 DC74". *Minor Planet Bulletin* **32**, 76-78

Almeida, R., Angeli, C.A., Duffard, R., and Lazzaro, D. (2004). "Rotation Period for Small Main Belt Asteroids" *Astron. Astrophys.* **403**, 403-406.

Galád, A., Pravec, P., Kušnirák, P., Gajdoš, Š., Kornoš, L., and Világi, J. (2005). "Joint Lightcurve Observations of 10 Near-Earth Asteroids from Modra and Ondřejov". *Earth, Moon, and Planets* **97**, 147-163.

Hicks, M. and Truong, T. (2010). *The Astronomers Telegram*, ATEL #2833.

Higgins, D. (2008). *Minor Planet Bulletin* **35**, 30-32.

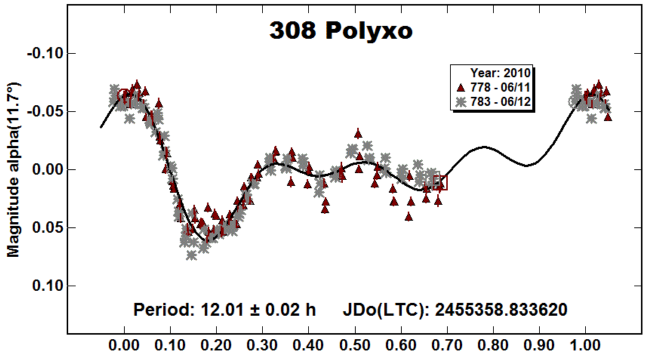
Higgins, D.J. (2010). Personal web site.
http://www.david-higgins.com/Astronomy/asteroid/lightcurves.htm

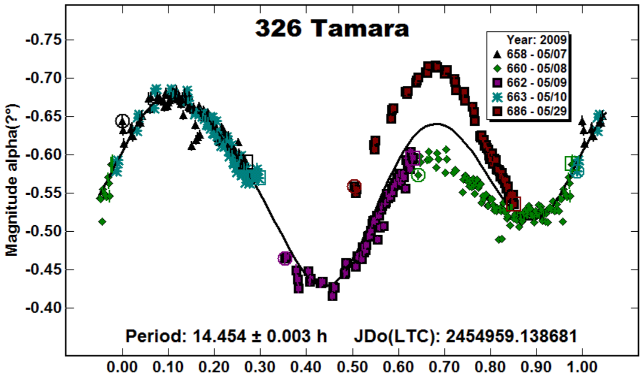
Higgins, D., Pravec, P., Kušnirák, P., Hornoch, K., Brinsfield, J.W., Allen, B., and Warner, B.D. (2008). *Minor Planet Bulletin* **35**, 123-126.

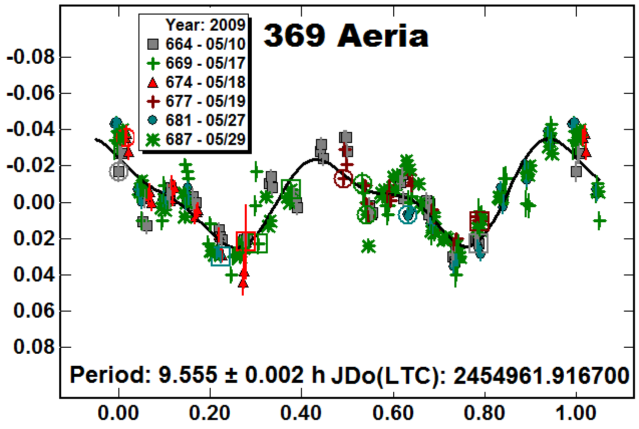
Pravec, P., Scheirich, P., Kušnirák, P., Šarounová, L., Mottola, S., Hahn, G., Brown, P., Esquerdo, G., Kaiser, N., Krzeminski, Z., Pray, D. P., Warner, B. D., Harris, A. W., Nolan, M. C., Howell, E. S., Benner, L. A. M., Margot, J.-L., Galád, A., Holliday, W., Hicks, M. D., Krugly, Yu. N., Tholen, D.,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

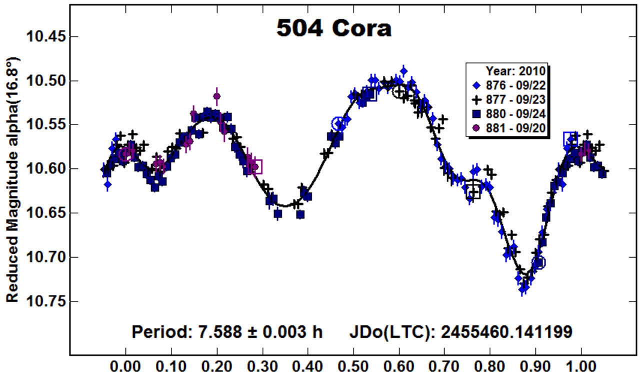
Stephens, R.D. (2010). Posting on CALL web site:
http://www.minorplanetobserver.com/Data/submissions_results.htm

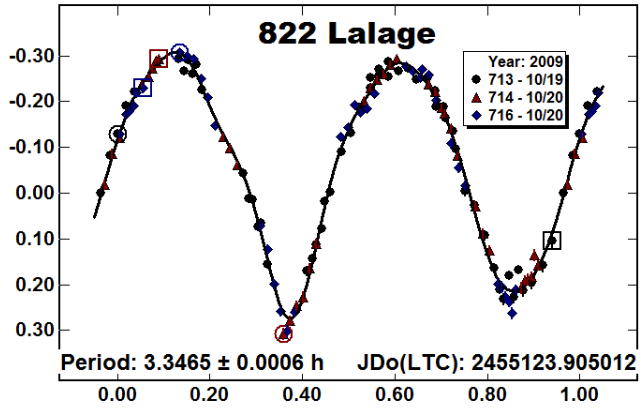
Warner, B. D., Harris, A., and Pravec, P. (2010). *Asteroid Lightcurve List*, 2010 May 21:
http://www.minorplanetobserver.com/astlc/lclist_pub_May2010.zip

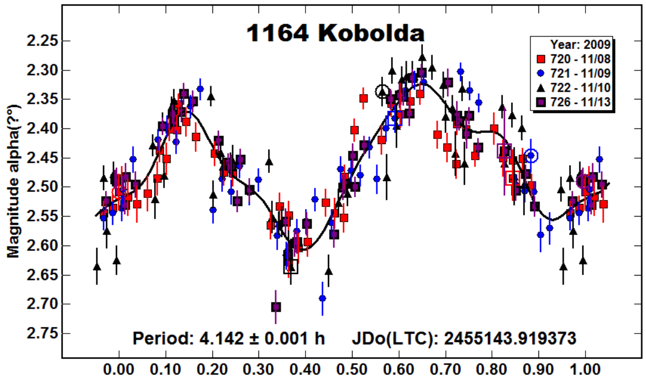


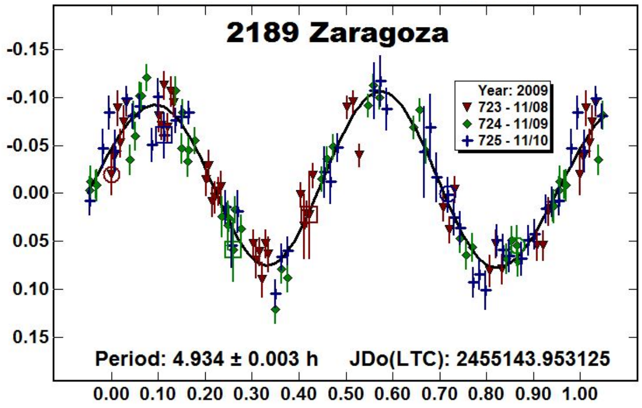


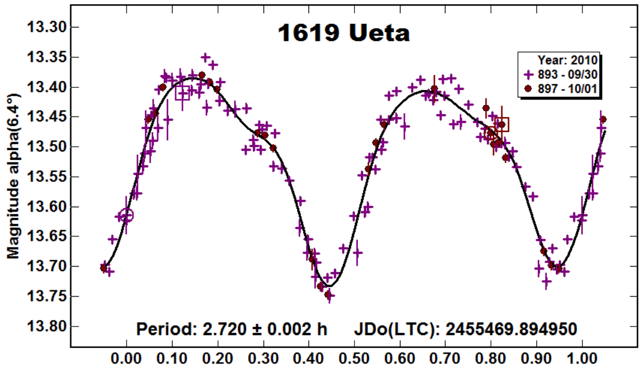


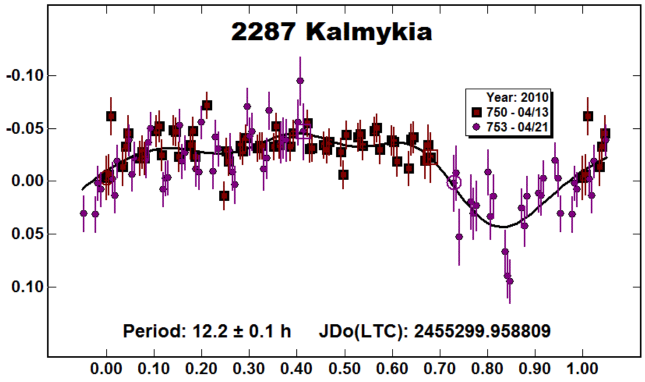


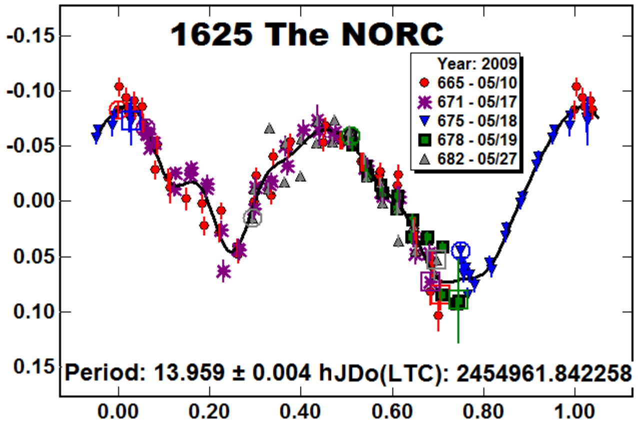


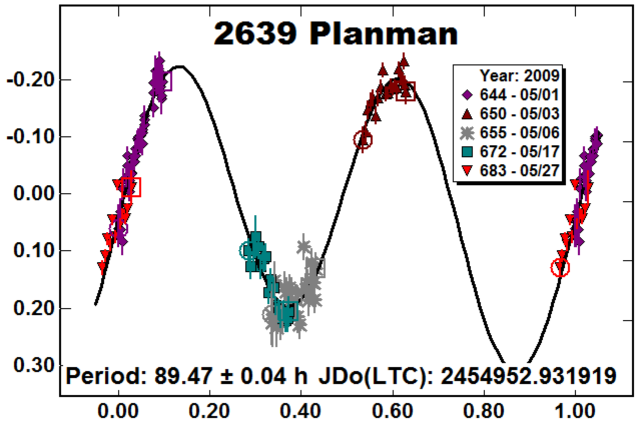

1164 Kobolda
Magnitude alpha(?°)
2.25
2.30
2.35
2.40
2.45
2.50
2.55
2.60
2.65
2.70
2.75
Year: 2009
720 - 11/08
721 - 11/09
722 - 11/10
726 - 11/13
Period: 4.142 ± 0.001 h
JDo(LTC): 2455143.919373
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

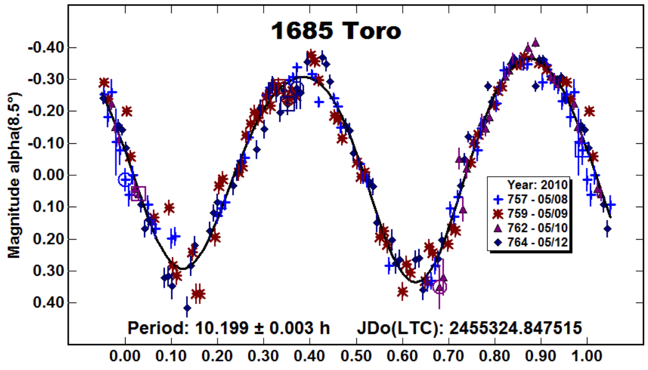

2189 Zaragoza
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
Year: 2009
723 - 11/08
724 - 11/09
725 - 11/10
Period: 4.934 ± 0.003 h
JDo(LTC): 2455143.953125
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

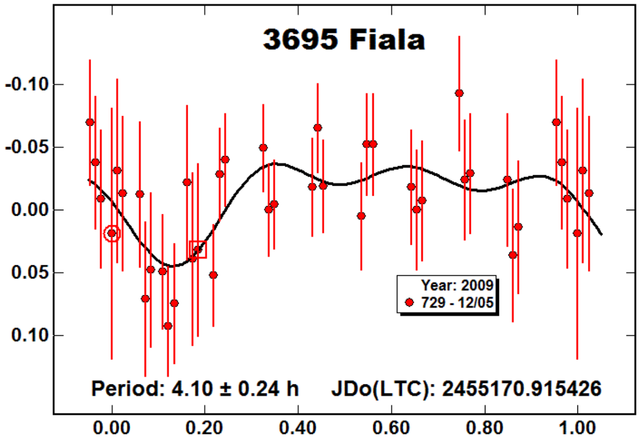

1619 Ueta
Magnitude alpha(6.4°)
13.30
13.35
13.40
13.45
13.50
13.55
13.60
13.65
13.70
13.75
13.80
Year: 2010
893 - 09/30
897 - 10/01
Period: 2.720 ± 0.002 h
JDo(LTC): 2455469.894950
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

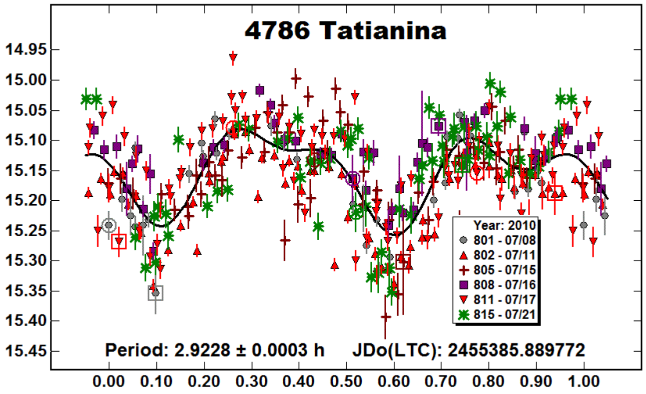

2287 Kalmykia
-0.10
-0.05
0.00
0.05
0.10
Year: 2010
750 - 04/13
753 - 04/21
Period: 12.2 ± 0.1 h
JDo(LTC): 2455299.958809
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

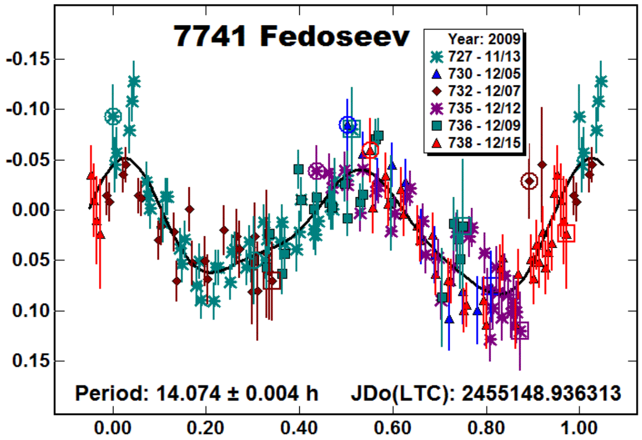

1625 The NORC
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
Year: 2009
665 - 05/10
671 - 05/17
675 - 05/18
678 - 05/19
682 - 05/27
Period: 13.959 ± 0.004 h
JDo(LTC): 2454961.842258
0.00
0.20
0.40
0.60
0.80
1.00

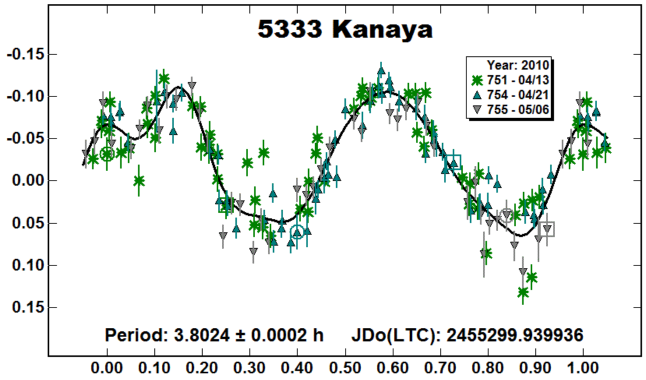

2639 Planman
-0.20
-0.10
0.00
0.10
0.20
0.30
Year: 2009
644 - 05/01
650 - 05/03
655 - 05/06
672 - 05/17
683 - 05/27
Period: 89.47 ± 0.04 h
JDo(LTC): 2454952.931919
0.00
0.20
0.40
0.60
0.80
1.00

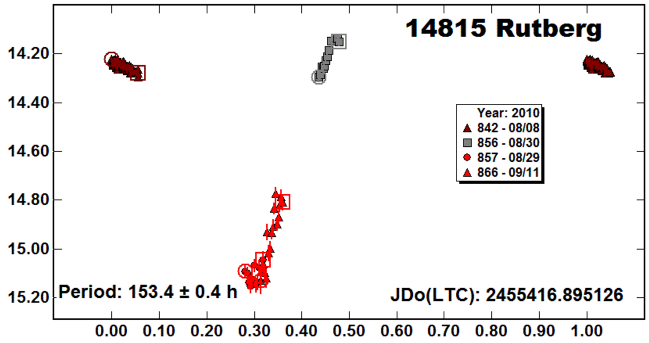

1685 Toro
Magnitude alpha(8.5°)
-0.40
-0.30
-0.20
-0.10
0.00
0.10
0.20
0.30
0.40
Year: 2010
757 - 05/08
759 - 05/09
762 - 05/10
764 - 05/12
Period: 10.199 ± 0.003 h
JDo(LTC): 2455324.847515
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

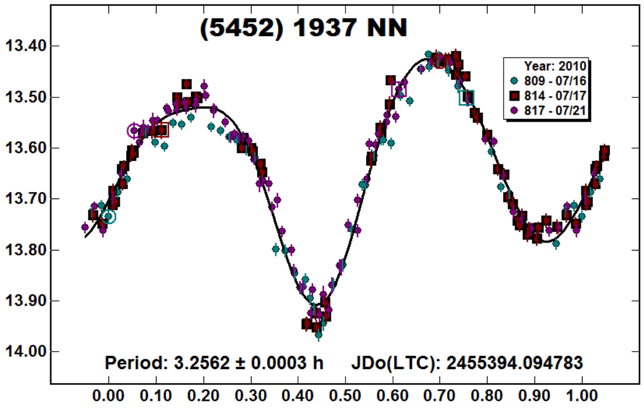

3695 Fiala
-0.10
-0.05
0.00
0.05
0.10
Year: 2009
729 - 12/05
Period: 4.10 ± 0.24 h
JDo(LTC): 2455170.915426
0.00
0.20
0.40
0.60
0.80
1.00

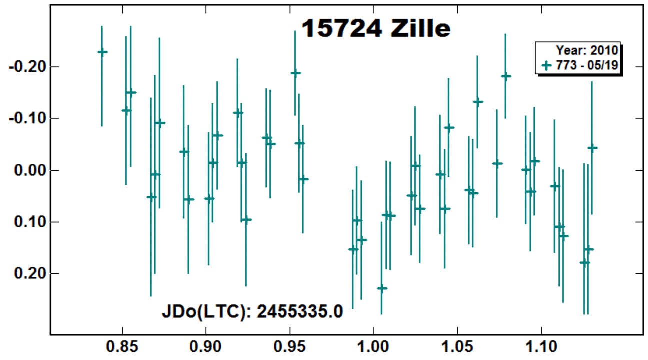

4786 Tatianina
Year: 2010
801 - 07/08
802 - 07/11
805 - 07/15
808 - 07/16
811 - 07/17
815 - 07/21
Period: 2.9228 ± 0.0003 h
JDo(LTC): 2455385.889772
14.95
15.00
15.05
15.10
15.15
15.20
15.25
15.30
15.35
15.40
15.45
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

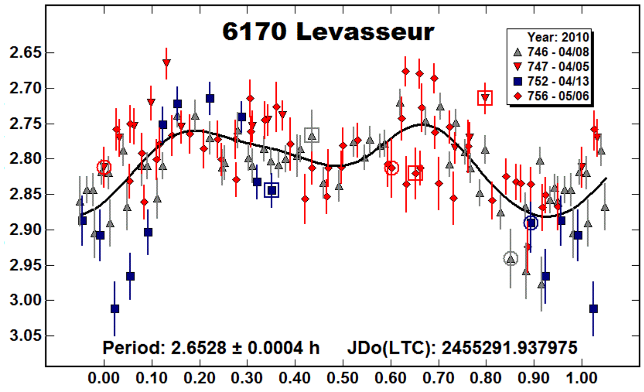

7741 Fedoseev
Year: 2009
727 - 11/13
730 - 12/05
732 - 12/07
735 - 12/12
736 - 12/09
738 - 12/15
Period: 14.074 ± 0.004 h
JDo(LTC): 2455148.936313
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.00
0.20
0.40
0.60
0.80
1.00

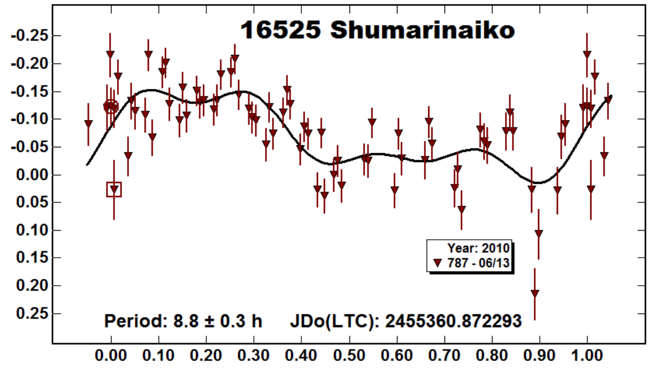

5333 Kanaya
Year: 2010
751 - 04/13
754 - 04/21
755 - 05/06
Period: 3.8024 ± 0.0002 h
JDo(LTC): 2455299.939936
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

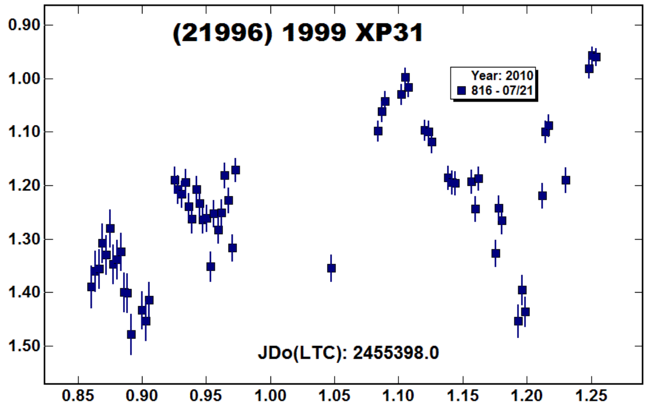

14815 Rutberg
Year: 2010
842 - 08/08
856 - 08/30
857 - 08/29
866 - 09/11
Period: 153.4 ± 0.4 h
JDo(LTC): 2455416.895126
14.20
14.40
14.60
14.80
15.00
15.20
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

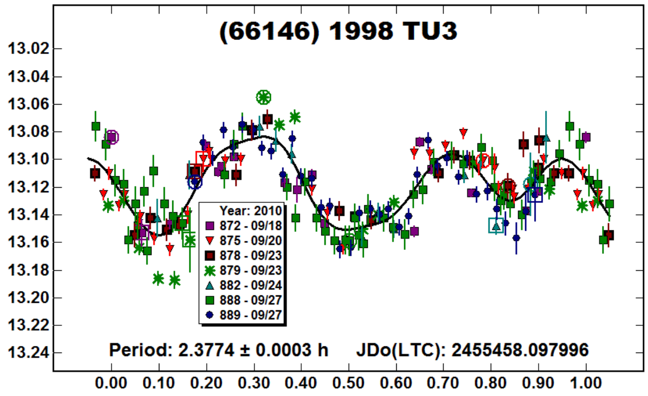

(5452) 1937 NN
Year: 2010
809 - 07/16
814 - 07/17
817 - 07/21
Period: 3.2562 ± 0.0003 h
JDo(LTC): 2455394.094783
13.40
13.50
13.60
13.70
13.80
13.90
14.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

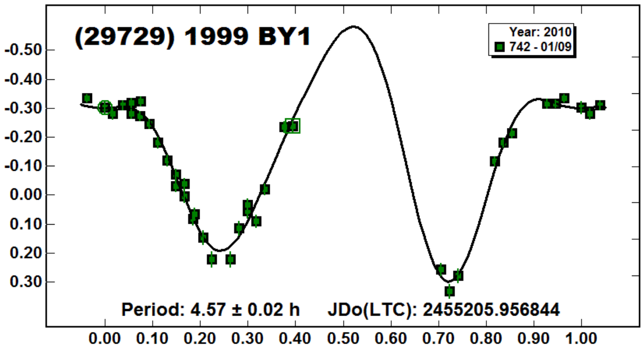

15724 Zille
Year: 2010
773 - 05/19
JDo(LTC): 2455335.0
-0.20
-0.10
0.00
0.10
0.20
0.85
0.90
0.95
1.00
1.05
1.10

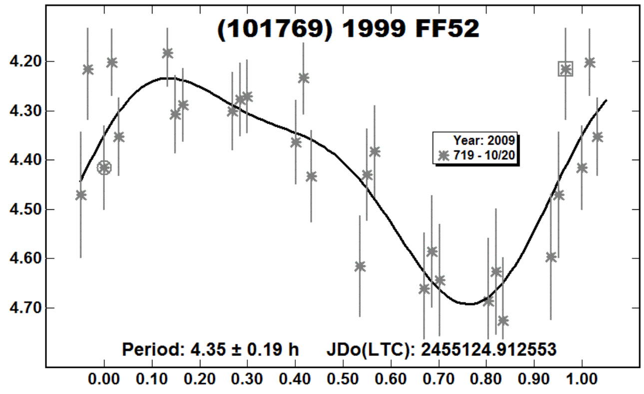

6170 Levasseur
Year: 2010
746 - 04/08
747 - 04/05
752 - 04/13
756 - 05/06
Period: 2.6528 ± 0.0004 h
JDo(LTC): 2455291.937975
2.65
2.70
2.75
2.80
2.85
2.90
2.95
3.00
3.05
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

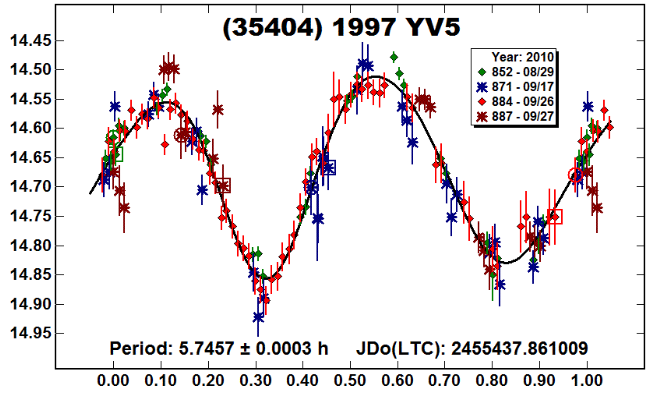

16525 Shumarinaiko
Year: 2010
787 - 06/13
Period: 8.8 ± 0.3 h
JDo(LTC): 2455360.872293
-0.25
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

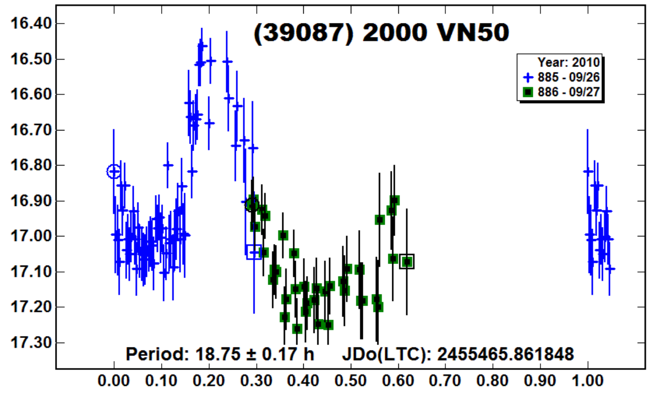












PERIOD DETERMINATION OF BINARY ASTEROID TARGETS OBSERVED AT HUNTERS HILL OBSERVATORY: MAY-SEPTEMBER 2009

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

Julian Oey
Leura Observatory
Leura, NSW, AUSTRALIA

Petr Pravec
Astronomical Institute
CZ-25165 Ondrejov, CZECH REPUBLIC

(Received: 11 October)

Lightcurves for seven confirmed or possible binary asteroids were obtained at the Hunters Hill Observatory (HHO) and Leura Observatory from 2009 May through 2010 September: 1453 Fennia, 2501 Lohja, 3076 Garber, 4029 Bridges, 5325 Silver, 6244 Okamoto, and (6265) 1985 TW3.

Observations of seven minor planets were obtained at Hunters Hill Observatory using a 0.36-m f/4 Meade LX200GPS S-C and SBIG ST-8E CCD camera. Exposures varied according to the brightness of the target. All were guided and taken through a clear filter. Observations at Leura Observatory were made using a 0.36-m f/4.6 Meade LX2000 Schmidt-Cassegrain and SBIG ST-9XE CCD

Camera. Image measurement and lightcurve analysis were done using the latest release or beta version of *MPO Canopus* at the time the target was observed. Analysis of the binary nature of these targets used the dual-period search function in *MPO Canopus* version 10.2.0.0. All data were sent to Petr Pravec, the principal investigator of the Binary Asteroid Photometric Survey (Pravec *et al.*, 2006), and analysed independently. His advice and guidance ensured that both sets of results were in agreement.

In the tables below, D_2/D_1 indicates the size ratio of the secondary and primary. An asterisk indicates the year of discovery.

1453 Fennia. This target was discovered to be a binary system by B.D. Warner in 2007 (Warner *et al.*, 2007). The target was observed during the 2009 apparition, confirming its binary nature (see Table I). It should be noted that any small features outside the eclipsing events may be spurious.

Year	P_1 (h)	A (mag)	P_{orb} (h)	A_{orb} (mag)	D_2/D_1
2009	4.4124 ± 0.0004	0.13 ± 0.02	23.03	0.08	0.27
2007*	4.4121 ± 0.0001	0.18	22.99	0.09	0.28

Table I. Attributes of the 1453 Fennia binary system

2501 Lohja. This target was revealed as a possible binary or tumbler during its 2006 apparition when observed at HHO. The target was observed during its 2010 apparition at HHO and Leura Observatory in an effort to uncover anything new about the target. A dual-period search was undertaken and, like previous apparitions, an underlying period close to P_1 was indicated though not to sufficient precision to rule out an artifact of some sort. A synodic rotation period of 3.8086 ± 0.0001 h with an amplitude of 0.35 ± 0.01 mag was derived.

3076 Gaber. This target was observed by Oey at Leura Observatory and HHO. Oey determined a period of 2.6087 h with his own data However, combined with HHO data, a period of 2.7600 h is derived. The entire dataset could not be fit to the 2.6087 h period. Using the dual period search in *MPO Canopus*, the data revealed sufficient deviations to suggest a second period may be present but no obvious eclipsing events were seen. Table II gives the observed parameters.

P_1 (h)	A (mag)	P_2 or P_{orb} (h)	A_2 (mag)	D_2/D_1
2.7600 ± 0.0002	0.18 ± 0.02	NA	NA	NA

Table II. Attributes of the 3076 Garber, possible binary system

4029 Bridges. This target was discovered to be a binary by Higgins in 2006 (Higgins *et al.*, 2006a). The target was observed during its 2010 apparition, when its binary nature was confirmed (see Table III).

Year	P_1 (h)	A (mag)	P_2 (h)	A_2 (mag)	D_2/D_1
2010	3.5748 ± 0.0002	0.25 ± 0.02	16.30	0.07	0.25
2006*	3.5746 ± 0.0001	0.20	16.31	0.06	0.24

Table III. Attributes of the 4029 Bridges Binary system

5325 Silver. This was a new target for the BAPS team. The data revealed some possible attenuations but nothing concrete enough to warrant anything other than possible binary status. Table IV gives the observed parameters.

P_1 (h)	A (mag)	P_2 (h)	A_2 (mag)	D_2/D_1
4.02361 ± 0.00006	0.27 ± 0.02	NA	NA	NA

Table IV. Attributes of the 5325 Silver, possible binary system

6244 Okamoto. This target was discovered to be binary by Higgins in 2006 (Higgins *et al.*, 2006b). The target was observed in its 2009 apparition, when mutual events confirmed the binary nature (see Table V). The data set was not sufficient to find a unique period for the orbit (P_{orb}). Equal quality fits were found at 20.04 h and 20.60 h but the period of 20.32 h was chosen since it matched the previous apparition, when the data set allowed a unique solution for P_{orb}.

Year	P_1 (h)	A (mag)	P_{orb} (h)	A_{orb} (mag)	D_2/D_1
2009	2.89585 ± 0.00009	0.15 ± 0.02	20.32	0.06	0.23
2006*	2.8958 ± 0.0001	0.11	20.32	0.07	0.25

Table V. Attributes of the 6244 Okamoto Binary system

(6265) 1985 TW3. This target was discovered to be binary by Higgins in 2007 (Higgins *et al.*, 2007). The 2010 observations confirmed the discovery and refined the system parameters (see Table VI).

Year	P1 (h)	A (mag)	P_{orb} (h)	A_{orb} (mag)	D_2/D_1
2010	2.70932 ± 0.00008	0.35 ± 0.01	15.845	0.1	0.30
2007*	2.7091 ± 0.0001	0.28	15.86	0.06	0.24

Table VI. Attributes of the (6265) 1985 TW3 Binary system

References

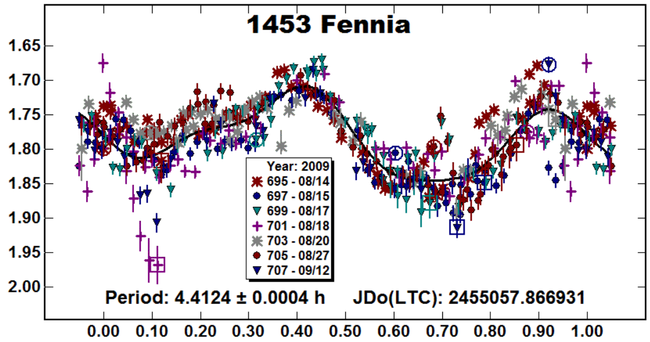
Pravec, P., Scheirich, P., Kušnirák, P., Šarounová, L., Mottola, S., Hahn, G., Brown, P., Esquerdo, G., Kaiser, N., Krzeminski, Z., Pray, D. P., Warner, B. D., Harris, A. W., Nolan, M. C., Howell, E. S., Benner, L. A. M., Margot, J.-L., Galád, A., Holliday, W., Hicks, M. D., Krugly, Yu. N., Tholen, D.,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

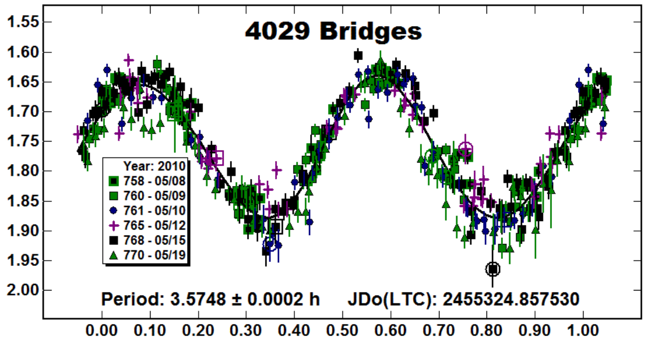
Higgins, D., Pravec, P., Kušnirák, P., Cooney Jr., W., Gross, J., Terrell, D., and Stephens, R.D. (2006a). CBET 570.

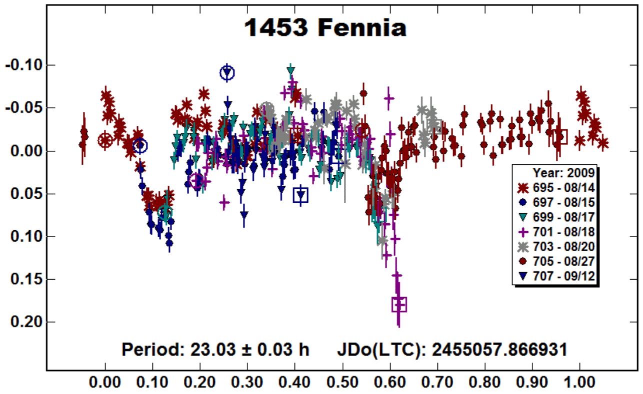
Higgins, D., Pray, D., Kušnirák, P., and Pravec, P. (2006). CBET 681.

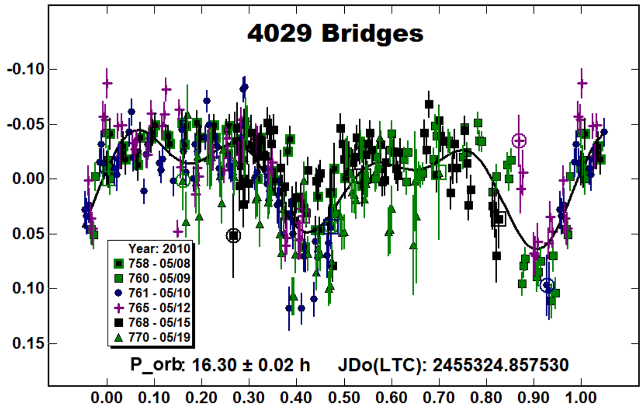
Higgins, D., Pravec, P. and Kušnirák, P. (2007). CBET 1015.

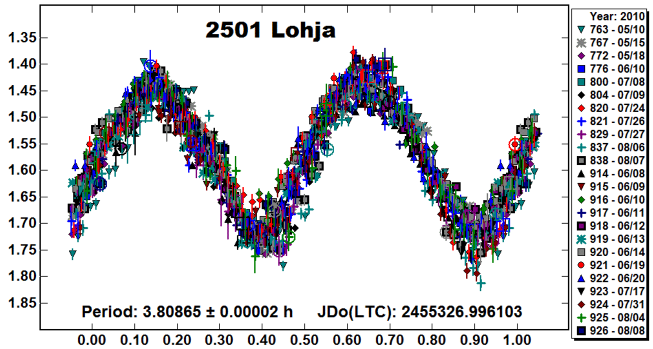
Warner, B.D., Harris, A.W., Pravec, P., Stephens, R.D., Pray, D., Cooney Jr., W., Gross, J., Terrell, D., Gajdoš, Š., Galád, A., and Krugly, Yu. (2007). CBET 1150.

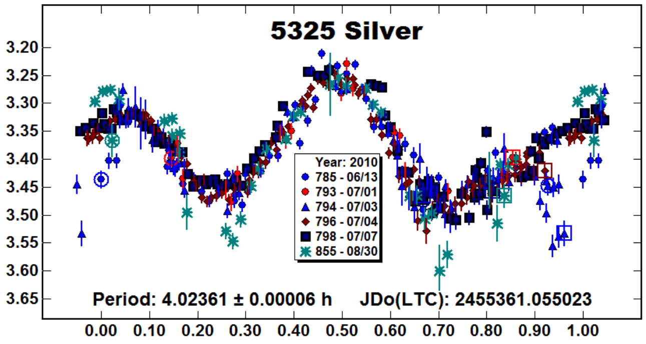

1453 Fennia
Year: 2009
695 - 08/14
697 - 08/15
699 - 08/17
701 - 08/18
703 - 08/20
705 - 08/27
707 - 09/12
Period: 4.4124 ± 0.0004 h JDo(LTC): 2455057.866931
1.65 1.70 1.75 1.80 1.85 1.90 1.95 2.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

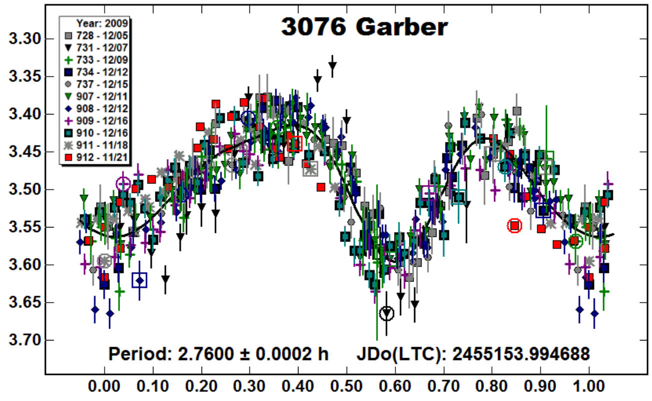

4029 Bridges
Year: 2010
758 - 05/08
760 - 05/09
761 - 05/10
765 - 05/12
768 - 05/15
770 - 05/19
Period: 3.5748 ± 0.0002 h JDo(LTC): 2455324.857530
1.55 1.60 1.65 1.70 1.75 1.80 1.85 1.90 1.95 2.00
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

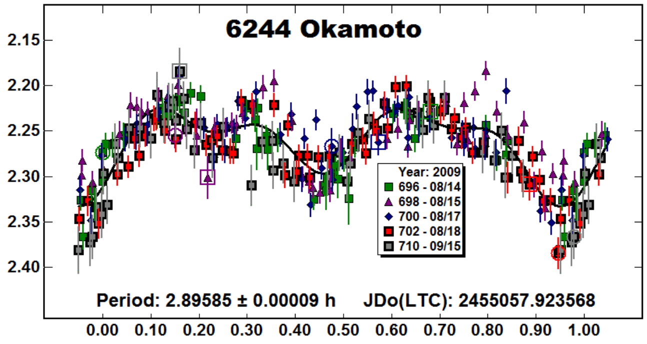

1453 Fennia
Year: 2009
695 - 08/14
697 - 08/15
699 - 08/17
701 - 08/18
703 - 08/20
705 - 08/27
707 - 09/12
Period: 23.03 ± 0.03 h JDo(LTC): 2455057.866931
-0.10 -0.05 0.00 0.05 0.10 0.15 0.20
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

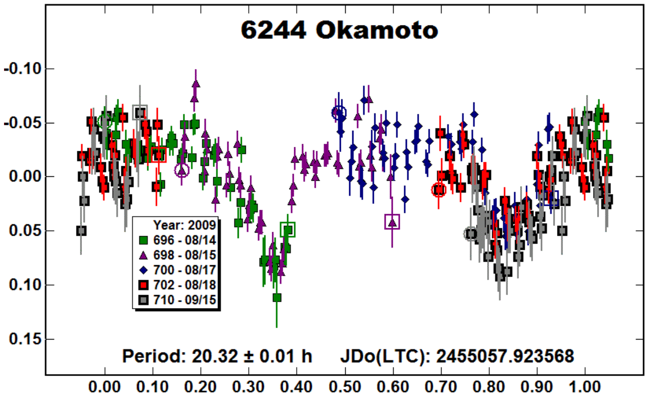

4029 Bridges
Year: 2010
758 - 05/08
760 - 05/09
761 - 05/10
765 - 05/12
768 - 05/15
770 - 05/19
P_orb: 16.30 ± 0.02 h JDo(LTC): 2455324.857530
-0.10 -0.05 0.00 0.05 0.10 0.15
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

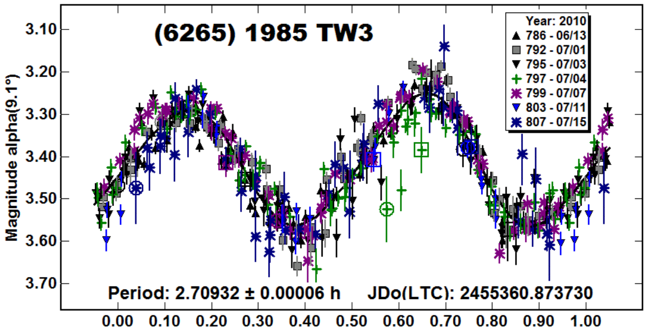

2501 Lohja
Year: 2010
763 - 05/10
767 - 05/15
772 - 05/18
776 - 06/10
800 - 07/08
804 - 07/09
820 - 07/24
821 - 07/26
829 - 07/27
837 - 08/06
838 - 08/07
914 - 06/08
915 - 06/09
916 - 06/10
917 - 06/11
918 - 06/12
919 - 06/13
920 - 06/14
921 - 06/19
922 - 06/20
923 - 07/17
924 - 07/31
925 - 08/04
926 - 08/08
Period: 3.80865 ± 0.00002 h JDo(LTC): 2455326.996103
1.35 1.40 1.45 1.50 1.55 1.60 1.65 1.70 1.75 1.80 1.85
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

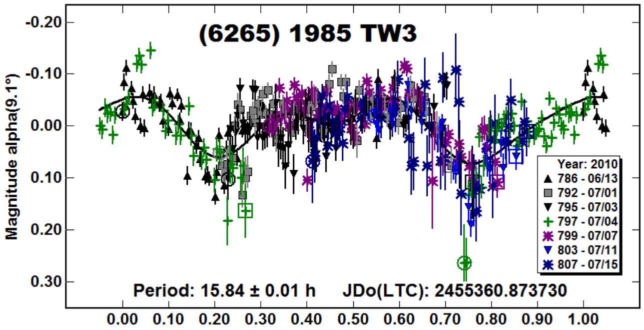

5325 Silver
Year: 2010
785 - 06/13
793 - 07/01
794 - 07/03
796 - 07/04
798 - 07/07
855 - 08/30
Period: 4.02361 ± 0.00006 h JDo(LTC): 2455361.055023
3.20 3.25 3.30 3.35 3.40 3.45 3.50 3.55 3.60 3.65
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


3076 Garber
Year: 2009
728 - 12/05
731 - 12/07
733 - 12/09
734 - 12/12
737 - 12/15
907 - 12/11
908 - 12/12
909 - 12/16
910 - 12/16
911 - 11/18
912 - 11/21
Period: 2.7600 ± 0.0002 h JDo(LTC): 2455153.994688
3.30 3.35 3.40 3.45 3.50 3.55 3.60 3.65 3.70
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


6244 Okamoto
Year: 2009
696 - 08/14
698 - 08/15
700 - 08/17
702 - 08/18
710 - 09/15
Period: 2.89585 ± 0.00009 h JDo(LTC): 2455057.923568
2.15 2.20 2.25 2.30 2.35 2.40
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00







PERIOD ANALISYS OF 996 HILARITAS, 3387 GREENBERG, AND 3870 MAYRE

Andrea Ferrero
Bigmuskie Observatory (B88)
via Italo Aresca 12, 14047 Mombercelli–Asti ITALY
bigmuskie@alice.it

(Received: 12 October)

The lightcurves for three asteroids were obtained at Bigmuskie Observatory, Italy, from 2010 March to June: 996 Hilaritas, 3387 Greenberg, and 3870 Mayre.

The rotation periods of three asteroids were found at the Bigmuskie Observatory from observations in 2010 March to June. 996 Hilaritas was chosen from among the list of photometry targets for 2010 January-March (Warner *et al.*, 2010a). The other two targets, 3387 Greenberg and 3870 Mayre, were chosen from the lists of photometry opportunities for 2010 April-June (Warner *et al.*, 2010b) and 2010 July-September (Warner *et al.*, 2010c) because there was no reported set of lightcurve parameters for the pair and they were favorably placed for observations.

A 0.3-m f/8 Ritchey-Chretien with a Finger Lakes Max Cam CM-9 CCD camera under the control of *MaximDL* was used to acquire the unfiltered images. Data reduction was performed with *MPO Canopus* (Warner, 2010). For all the asteroids, every session of the curve was produced using 3 to 5 comparison stars that were chosen using the comparison star selector routine in *MPO Canopus*. This feature typically allows linking multiple sessions to ±0.05 mag. Every observing session started about 3.5 hours east of the meridian and ended about 4 hours west. Exposure times were 120 seconds for 996 Hilaritas and 180 seconds for 3387 Greenberg and 3870 Mayre.

996 Hilaritas. A period of 7.20 h had been previously reported by Angeli *et al.* (2001). It was evident from analysis of the first session's data with *MPO Canopus* that a different period would emerge. After three sessions, we found a period of $P = 10.05 \pm 0.01$ h, the same period reported by Stephens (2010).

3387 Greenberg. With a short period of $P = 2.70 \pm 0.02$ h, the solution was evident from inspection of the raw plot, where more than two complete cycles were recorded . With two sessions, four complete rotations of the asteroid were covered, giving the result a high degree of reliability.

3870 Mayre. Using data from three sessions, a secure bimodal curve with a period of $P = 3.99 \pm 0.01$ h was obtained.

References

Angeli, C.A., Guimaraes, T.A., Lazzaro, D., Duffard, R., Fernandez, S., Florczak, M., Monthé-Diniz, T., Carvano, J.M., and Betzler, A.S. (2001). "Rotation Periods for Small Main-Belt Asteroids from CCD Photometry." *Astron. J.* **121**, 2245-2252

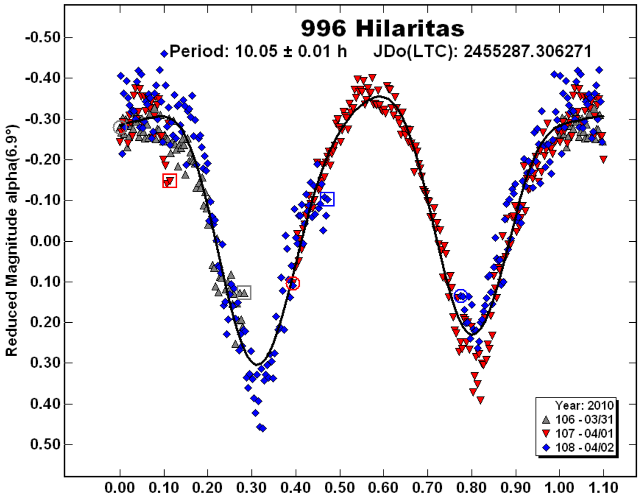
Stephens, R.D. (2010). "Asteroids Observed from GMARS and Santana Observatories: 2010 April - June." *Minor Planet Bulletin* **37**, 159-161.

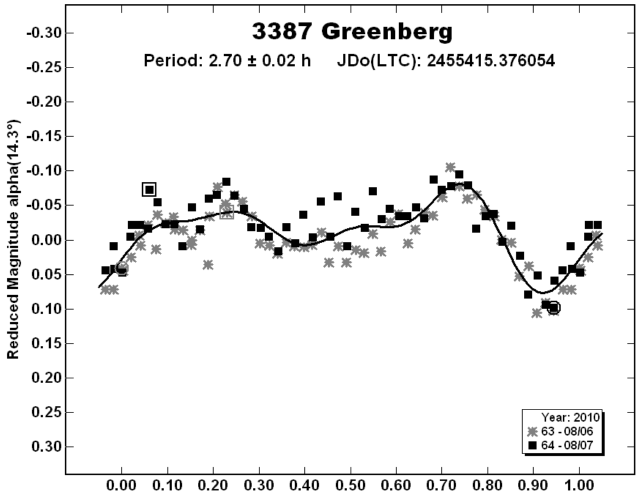
Warner, B. D. (2010). *MPO Canopus* version 10.1.0.6. Bdw Publishing, Colorado Springs, CO.

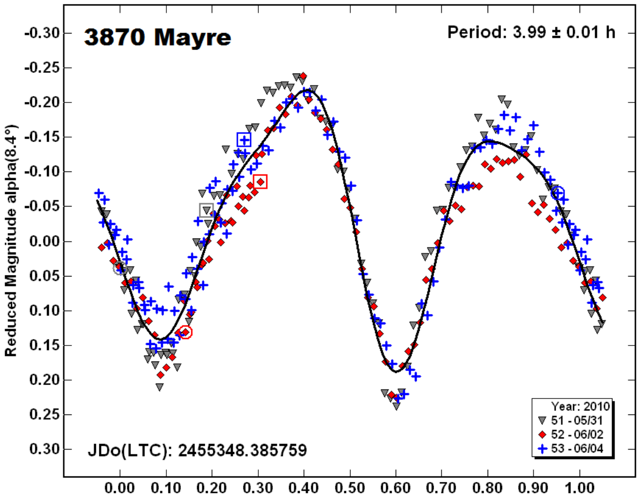
Warner, B.D., Harris A. W., Pravec, P., Durech J., and Benner L. A.M. (2010a). "Lightcurve Photometry Opportunities: 2010 January – March." *Minor Planet Bulletin* **37**, 37-39.

Warner, B.D., Harris A. W., Pravec, P., Durech J., and Benner L. A.M. (2010b). "Lightcurve Photometry Opportunities: 2010 April July." *Minor Planet Bulletin* **37**, 77-79.

Warner, B.D., Harris A. W., Pravec, P., Durech J., and Benner L. A.M. (2010c). "Lightcurve Photometry Opportunities: 2010 July-September." *Minor Planet Bulletin* **37**, 130-133.







ROTATION PERIOD DETERMINATIONS FOR 27 EUTERPE, 296 PHAETUSA, AND 672 ASTARTE, AND A NOTE ON 65 CYBELE

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

(Received: 12 October Revised: 21 October)

Synodic rotation periods and amplitudes have been found for 27 Euterpe 10.407 ± 0.001 h, 0.16 ± 0.02 mag; 65 Cybele no period found, 0.01 ± 0.01 mag; 296 Phaetusa 4.5385 ± 0.0001 h, maximum 0.51 ± 0.03 mag; 672 Astarte 22.572 ± 0.002 h, 0.15 ± 0.02 mag.

Observations of all of these objects were made at the Organ Mesa Observatory with a Meade 35 cm LX200 GPS S-C, SBIG STL-1001E CCD, differential photometry only, unguided exposures, red filter for 27 Euterpe, clear filter for all other objects. *MPO Canopus* software was used to measure the images photometrically and prepare the lightcurves. Due to the large number of data points acquired the lightcurves have been binned in sets of three data points with a maximum of five minutes between points.

27 Euterpe. Chang and Chang (1962) made the first period determination of 8.5 hours, and this value was believed for many years. Stephens et al. (2001) and Stephens (2001) in companion articles found a period of 10.410 hours with an irregular lightcurve. Subsequent determinations have been in close agreement and also show irregular lightcurves which are very different at different longitudes. These are by Gandolfi et al. (2009), 10.377 h, and by Stephens (2010), 10.404 h. New observations on five nights 2010 June 12 – July 15 show a period of 10.407 ± 0.001 hours, amplitude 0.16 ± 0.02 magnitudes, one somewhat irregular maximum and minimum per cycle, with complete phase coverage except for a small part of the rising portion lost to passing clouds. This is compatible with all recent determinations.

65 Cybele. Previous findings of the rotation period have been bivalued. Schober et al. (1980), Weidenschilling et al. (1987), and Pilcher and Stephens (2010) all found periods near 6.07 hours. Weidenschilling et al. (1990), Gil-Hutton (1990), Drummond et al. (1991), De Angelis (1995), Shevchenko et al. (1996), and Behrend (2009) all obtained periods near 4.03 hours. Amplitudes of 0.04 to 0.12 magnitudes have been reported. A new lightcurve was obtained 2010 Sept. 24. It extended more than 6 hours and therefore covered the complete cycle for either of the discordant periods. An amplitude only 0.01 ± 0.01 magnitude was found, much smaller than at any previously observed apparition. This shows that one of the two rotational poles is located within a few degrees of the position on the night of observations, longitude 53 degrees, latitude –4 degrees. But this amplitude is too small to allow a resolution of the period ambiguity. No further observations were made because it was more productive to schedule telescope time on other targets.

296 Phaetusa. Minor planet 296 Phaetusa is the lowest numbered asteroid for which the Asteroid Lightcurve Data File (Harris et al. 2010) shows no previous observations. With a period of revolution 3 1/3 years and a moderately eccentric orbit, in 2010 Sept. – Oct. it was much more favorably placed for observation than at any time since 2000 or until 2020. The former

circumstance probably explains the absence of previous observations. The latter circumstance is the reason this writer placed high priority on its observation at the current apparition. Observations on 5 nights 2010 Sept. 9 – Oct. 12 show a period 4.5385 ± 0.0001 hours. The amplitude decreased from 0.51 ± 0.03 magnitudes at phase angle 21 degrees Sept. 9 to 0.38 ± 0.03 magnitudes at phase angle 4 degrees Oct. 12.

672 Astarte. Behrend (2010) states a period 19.8 hours based on partial coverage of an assumed symmetric bimodal lightcurve. New observations on 10 nights 2010 Aug. 16 – Sept. 26 rule out this assumption and show a period 22.572 ± 0.002 hours, amplitude 0.15 ± 0.02 magnitudes, with a somewhat irregular lightcurve.

References

Behrend, R. (2010). Observatoire de Geneve web site. http://obswww.unige.ch/~behrend/page_cou.html.

Chang, Y. C. and Chang, C.-s. (1962). "Photometric Investigations of Seven Variable Asteroids." *Acta Astron. Sin.* **10**, 101-111.

De Angelis, G. (1995). "Asteroid spin, pole, and shape determinations." *Planet. Space Sci.* **43**, 649-682.

Drummond, J. D., Weidenschilling, S. J., Chapman, C. R., and Davis, D. R. (1991). "Photometric Geodesy of Main-Belt Asteroids IV. An updated analysis of Lightcurves for Poles, Periods, and Shapes." *Icarus* **89**, 44-64.

Gandolfi, D., Cigna, M., Fulvio, D., and Blanco, C. (2009). "CCD and photon-counting photometric observations of asteroids carried out at Padova and Catania observatories." *Planet. Space Sci.* **57**, 1-9.

Gil-Hutton, R. (1990). "V+B Photoelectric Photometry of Asteroids 65 Cybele and 216 Kleopatra." *Minor Planet Bull.* **17**, 34-35.

Harris, A. W., Pravec, P., and Warner, B. D. (2010). "Asteroid Lightcurve Data File, May 21, 2010." http://www.MinorPlanetObserver.com/astlc/default.htm.

Pilcher, F. and Stephens, R. (2010). "Rotation Period Determination for 65 Cybele." *Minor Planet Bull.* **37**, 8.

Schober, H. J., Scaltriti, F., Zappala, V., and Harris, A. W. (1980). "The Remaining Large Minor Planets with Unknown Rotational Properties: 31 Euphrosyne and 65 Cybele." *Astron. Astrophys.* **91**, 1-6.

Shevchenko, V. G., Chiorny, V. G., Kalashnikov, A. V., Krugly, Yu. N., Mohamed, R. A., and Velichko, F. P. (1996). "Magnitude-phase dependences for three asteroids." *Astron. Astrophys. Suppl. Ser.* **115**, 475-479.

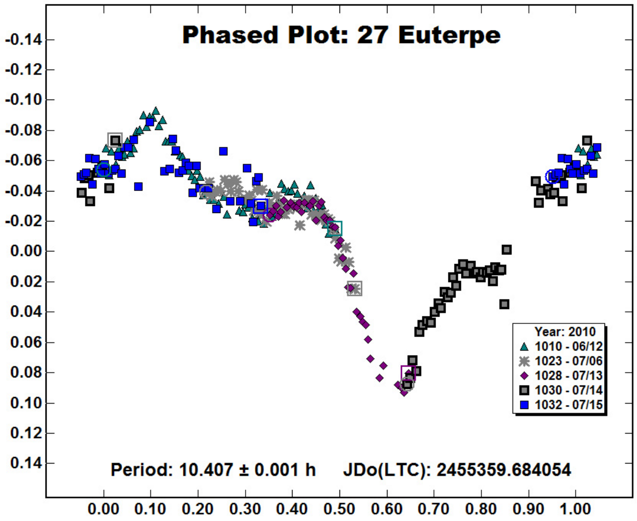
Stephens, R. D., Malcolm, G., Koff, R. A., Brincat, S. M., and Warner, B. (2001). "New Period Determination for 27 Euterpe, A Collaborative Project." *Minor Planet Bull.* **28**, 1-2.

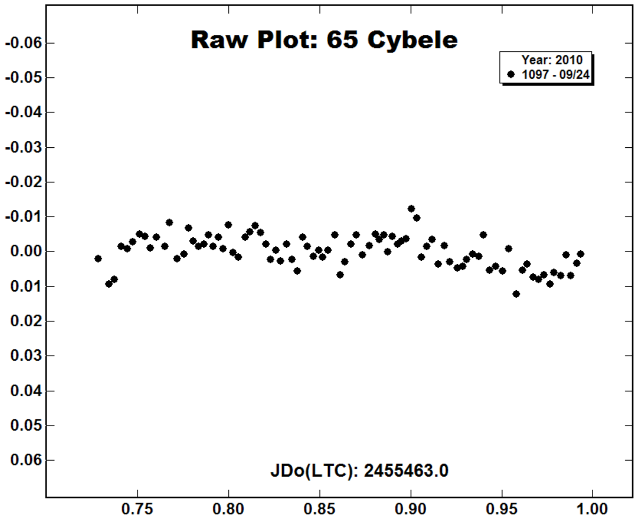
Stephens, R. D. (2001). "Combining Collaborative Work." *Minor Planet Bull.* **28**, 5-6.

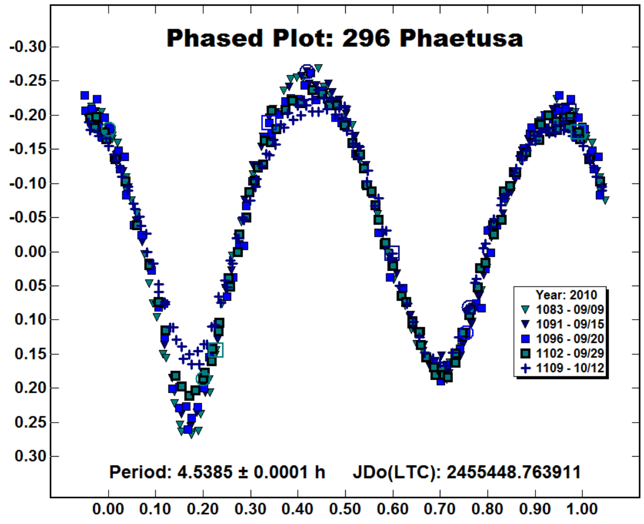
Stephens, R. (2010). "Asteroid Maven." *Sky and Telescope* **120**, 60-65

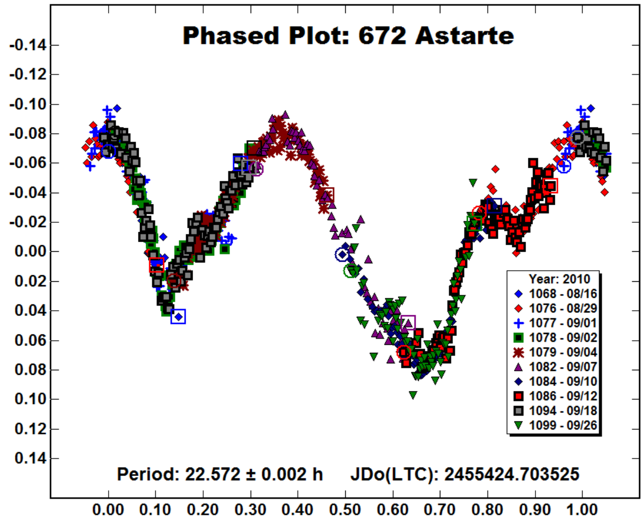
Weidenschilling, S. J., Chapman, C. R., Davis, D. R., Greenberg, R., Levy, D. H., and Vail, S. (1987). "Photometric Geodesy of Main-Belt Asteroids I. Lightcurves of 26 Large, Rapid Rotators." *Icarus* **70**, 191-245.

Weidenschilling, S. J., Chapman, C. R., Levy, D. H., Davis, D. R., Greenberg, R., Binzel, R. P., Vail, S. M., Magee, M., and Spaute, D. (1990). "Photometric Geodesy of Main-Belt Asteroids III Additional Lightcurves." *Icarus* **86**, 402-447.









UPON FURTHER REVIEW: IV. AN EXAMINATION OF PREVIOUS LIGHTCURVE ANALYSIS FROM THE PALMER DIVIDE OBSERVATORY

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

(Received: 12 October Revised: 8 November)

Updated results are given for nine asteroids previously reported from the Palmer Divide Observatory (PDO). The original images were remeasured 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 were moderately different were found for 573 Recha, 575 Renate, 605 Juvisia, 620 Drakonia, 687 Tinette, 787 Moskva, 983 Gunila, 1282 Utopia, and 1600 Vyssotsky. This is one in a series of papers that examines 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 (ca 1999-2006). In most cases, any changes in the period and/or amplitude as a result of the new analysis were statistically insignificant. Some, however, fit into a gray area between significant and not but are still worth noting. This paper is one in a series that reports updated results from the initial stage of new analysis, in this case giving updates on six asteroids that fit into that gray area. Subsequent stages will likely produce additional revisions.

For background on the justification and methodology of this project, see the first paper in the series (Warner, 2010).

Presentation of the New Analysis

A brief analysis of the new data set and lightcurve based on that new data set are given below, 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 higher rating; see Warner et al., 2009, for information about the U code rating system). The exact observing details will not be given. Instead, Table I lists the original and new results along with a reference to the original

		Original				Revised				
#	Name	Per	Amp	U	Ref	Per	PE	Amp	AE	U
573	Recha	6.53	0.25	0	Warner; MPB 29, 14-15	7.15	0.01	0.20	0.02	2+
575	Renate	3.678	0.20	2	Warner; MPB 27, 4-6	3.676	0.002	0.15	0.01	3-
605	Juvisia	15.855	0.26	2	Warner; MPB 24, 4-6	15.93	0.02	0.25	0.01	2
620	Drakonia	5.485	0.52	3	Warner; MPB 29, 27-28	5.49	0.01	0.56	0.02	3
687	Tinette	7.395	0.33	3	Warner; MPB 27, 4-6	7.40	0.02	0.25	0.01	3
787	Moskva	5.381	0.55	2	Warner; MPB	6.056	0.001	0.62	0.01	3
983	Gunila				Not previously published	Long?				1
1282	Utopia	13.60	0.29	3	Warner; MPB 28, 30-32	13.61	0.01	0.28	0.01	3
1600	Vyssotsky	3.2	0.13	2	Warner; MPB 26, 31-33	3.201	0.001	0.19	0.01	3

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.

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).

573 Recha. The revised data set found the "correct" period subsequently found by the author and others.

575 Renate. There was no significant change in the period with the new data set but it was cleaner than the original and allowed an improved U code rating.

605 Juvisia. The revised data set found a slightly longer period. The precision of the period and error were decreased to reflect the period and span of the data set.

620 Drakonia. The period, amplitude, and U code rating were essentially unchanged from before. However, the precision of the results were decreased to be more in line with the period and span of the observations.

687 Tinette. This is another case where the precision of the results was decreased to give a more realistic indication of the solution.

787 Moskva. The original data set from 1999 found a much different period. This was due in part to losing a good portion of the curve due to an interfering star. The star subtraction feature of *MPO Canopus* restored most of the data, which lead to a solution in line with that subsequently found by the author and others.

983 Gunila. The results for this asteroid were not previously published. Taken at face value, the two, widely-separated sessions show a 0.1 mag increase, indicating a possible long period. A raw plot of each night shows almost flat lightcurve, so an obvious short period is ruled out – unless the viewing aspect was pole on and so the curve could be flat regardless of period. The data are included here only to put them "on the record" should future analysis find them useful.

1282 Utopia. The revised analysis was able to recover some data points lost due to a field star. The results are essentially the same as before.

1600 Vyssotsky. The 1999 data set was relatively noisy, which affected previous attempts to model the asteroid (Warner et al., 2008). This revised data set should prove useful in follow-up attempts to model the asteroid's spin axis and shape.

Acknowledgements

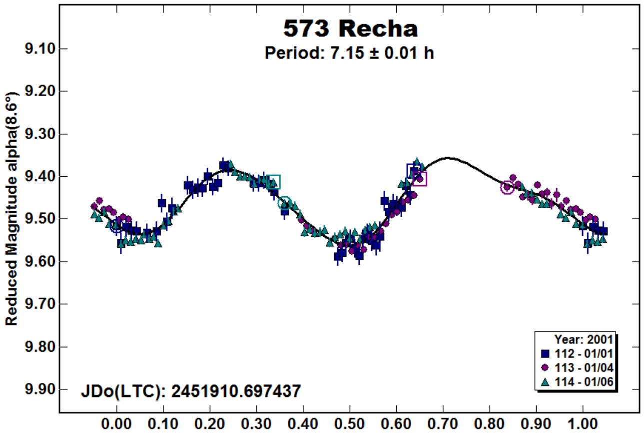
Funding for observations and research at the Palmer Divide Observatory is currently provided by NASA grant NNX 10AL35G, by National Science Foundation grant AST-1032896 and by a 2007 Gene Shoemaker NEO Grant from the Planetary Society.

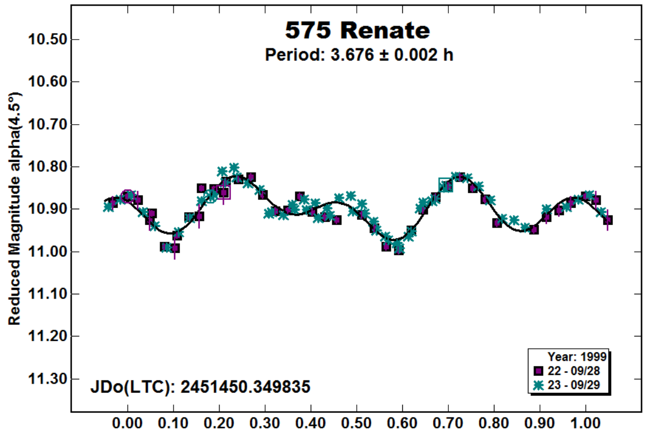
References

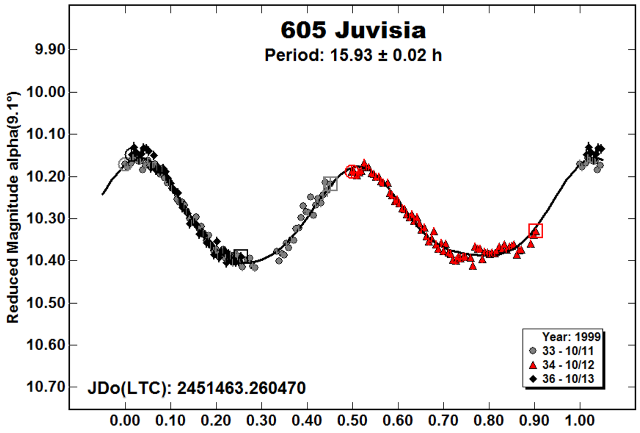
Warner, B.D., Higgins, D., Pray, D.P., Dyvig, R., Reddy, V., and Durech, J. (2008). "A Shape and Spin Axis Model for 1600 Vyssotsky." *Minor Planet Bul.* **35**, 13-14.

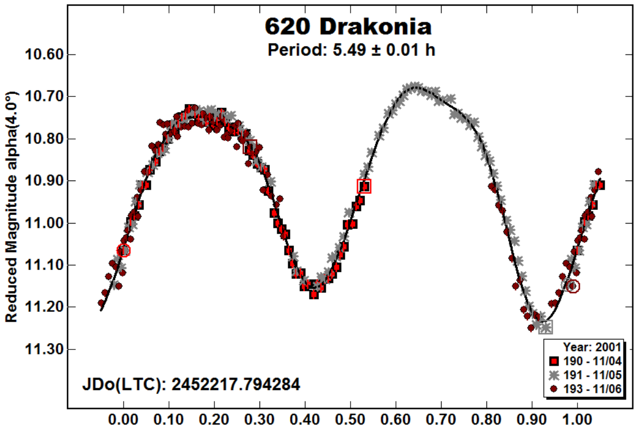
Warner, B.D., Harris, A.W., and Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146.

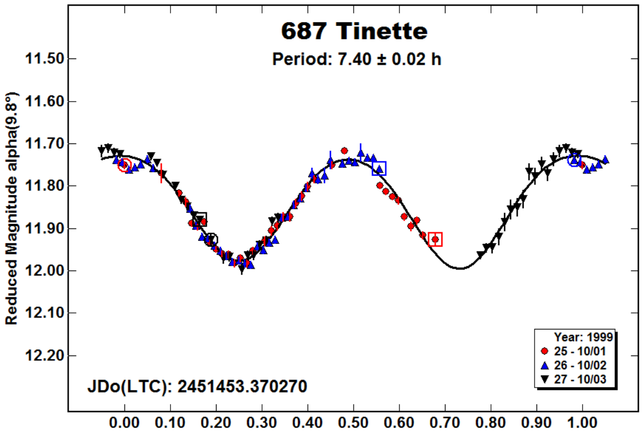
Warner, B.D. (2010). "Upon Further Review: I. An Examination of Previous Lightcurve Analysis from the Palmer Divide Observatory." *Minor Planet Bulletin* 37, 127-130.

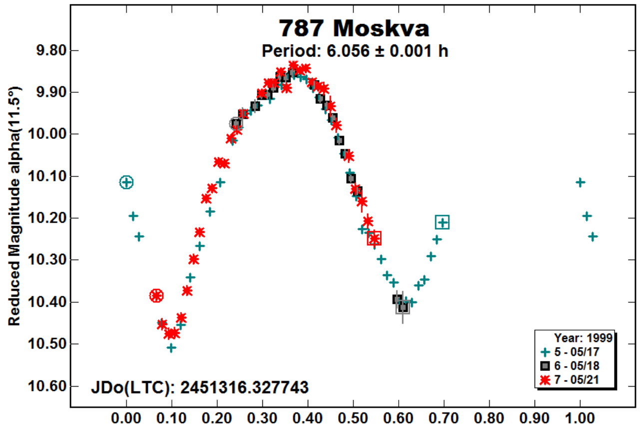


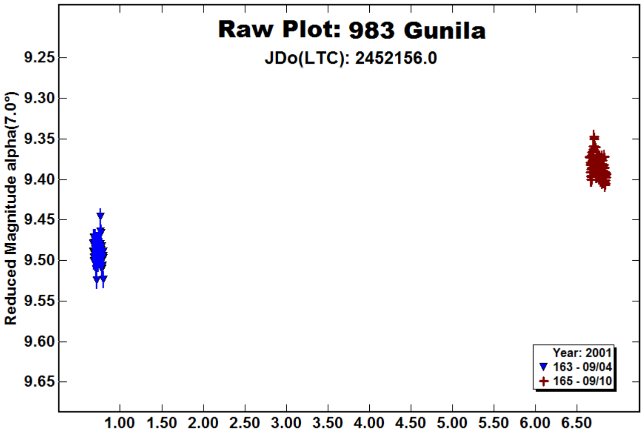


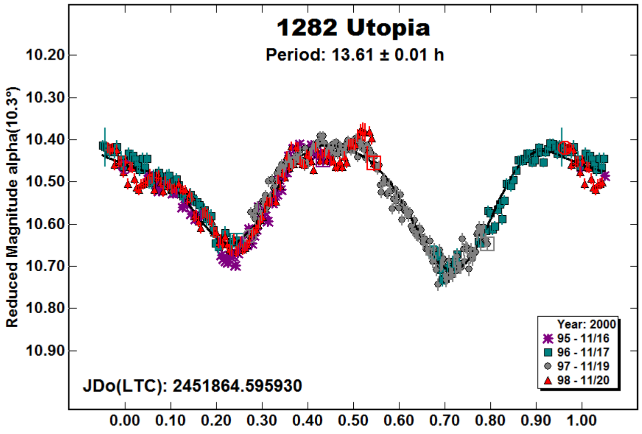


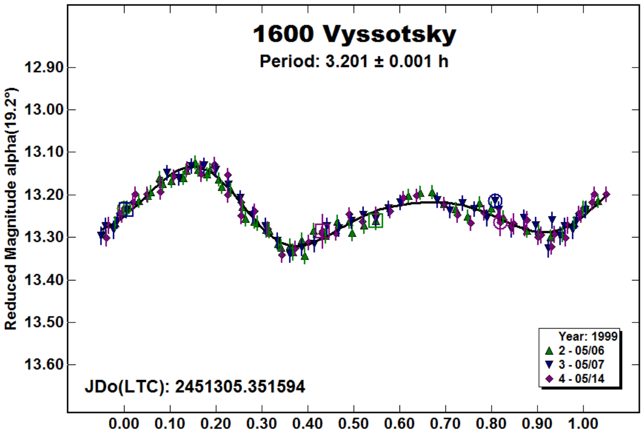












PERIOD DETERMINATION FOR 448 NATALIE

Eduardo Manuel Alvarez
Observatorio Los Algarrobos (OLASU)
Costanera Sur 559, Salto 50.000, URUGUAY
olasu@adinet.com.uy

(Received: 13 October)

Lightcurve analysis for 448 Natalie was performed from observations during its 2010 opposition. The synodic rotation period was found to be 8.0646 ± 0.0004 h and the lightcurve amplitude was 0.32 ± 0.04 mag.

As of early September 2010, only 6 of the first 500 numbered asteroids appeared to have no previously reported rotation periods (only four years ago, that number was seven times greater). One of those six, 448 Natalie, was chosen for observations since it would be favorably placed for several weeks during the 2010 apparition and because it was one of the recommended asteroids in the “Potential Lightcurve Targets 2010 July - September” included at the Collaborative Asteroid Lightcurve Link (CALL) web-site (Warner, 2010).

The asteroid was observed from 2010 mid-September to early October at Observatorio Los Algarrobos, Salto, Uruguay (MPC Code I38), using a 0.3-m Meade LX-200R working at f/6.3 with a focal reducer. The CCD imager was a QSI 516wsg NABG with a 1536 x 1024 array of 9-micron pixels. Exposures were 60 s working at –10C, unguided, and unfiltered at 2x2 binning, yielding an image scale of 1.9 arcseconds per pixel. All images were dark and flat field corrected. The images were measured using *MPO Canopus* version 10.2.0.2 (Bdw Publishing) with a differential photometry technique. The data were light-time corrected. Period analysis was also done with *Canopus*, which incorporates the Fourier analysis algorithm developed by Harris (Harris *et al.*, 1989).

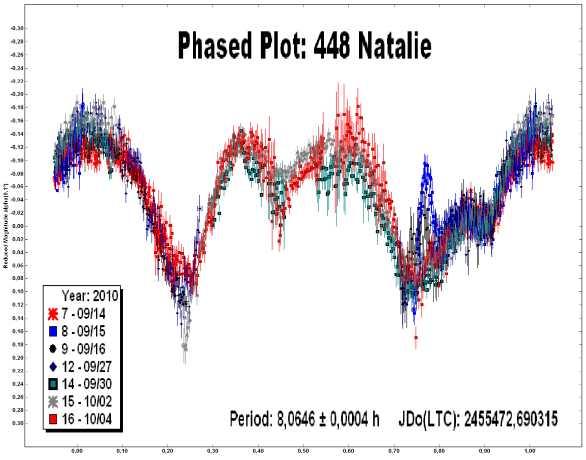
From more than 2,200 data points obtained during 7 sessions, (2 of them longer than 7 h and totaling in all more than 35 h), the synodic rotation period was found to be P = 8.0646 ± 0.0004 h with an amplitude of A = 0.32 ± 0.04 mag. During the time of the observations, the phase angle increased from 9.1º to 14.8º.

This leaves only five asteroids numbered below 500 for which no rotational parameters could be found. They are, in ascending order, 330 Adalberta, 398 Admete, 414 Liriope, 457 Alleghenia, and 473 Nolli.

References

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

Warner, B.D. Collaborative Asteroid Lightcurve Link (CALL) web site (2010).
http://www.minorplanetobserver.com/astlc/default.htm



CCD PHOTOMETRY AND LIGHTCURVE ANALYSIS OF 1730 MARCELINE AND 1996 ADAMS FROM OBSERVATORI CARMELITA IN TIANA

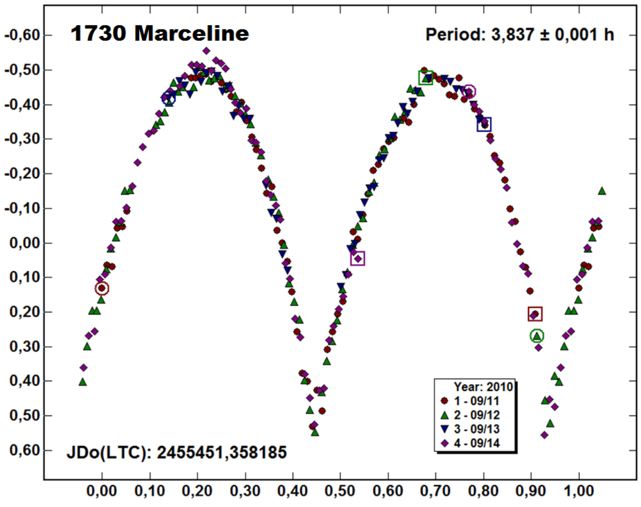
Josep Maria Aymamí
Observatori Carmelita (MPC B20)
Av. P. Lluïs Companys, 45, 08391 Tiana, Spain
pepienus@telefonica.net

(Received: 13 October)

Analysis of observations carried out during 2010 September and October determined the synodic periods of 1730 Marceline (1936 UA) and 1996 Adams (1961 UA). For main-belt asteroid 1730 Marceline, a period of 3.837 ± 0.001 h was found. For 1996 Adams, also an MBA, a period of 3.311 ± 0.001 h was determined. This differs from the period of 3.56 h found by Alvarez-Candal et al. (2004).

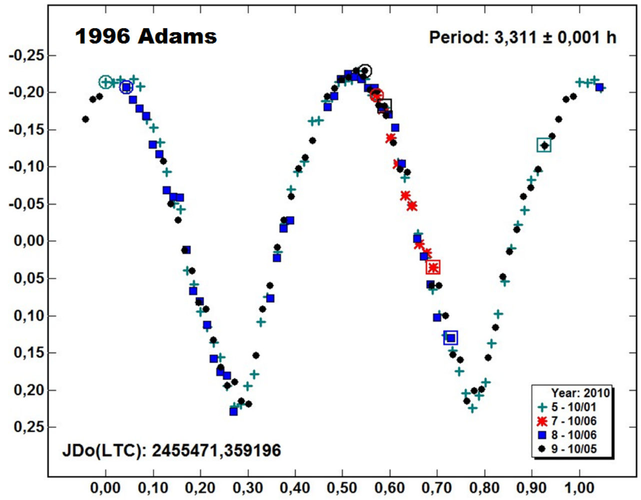
The *Carmelita Observatory* (MPC B20) is situated in the town of Tiana, in the southernmost part of the *Serra de Marina*, a moderately polluted suburban park 15 km north of Barcelona, Spain. The observatory is equipped with an Astro-Physics AP900 GEM (German Equatorial Mount) on a fixed pier, a 25-cm Schmidt-Cassegrain telescope with a focal reducer, and a dual-chip SBIG ST8-XME CCD camera with filter wheel yielding a 34.0 x 22.7 arc minute field of view and an effective resolution of 1.33 arc sec/pix.

<u>1730 Marceline</u>. This main-belt asteroid was discovered by French astronomer Marguerite Laugier at the Observatoire de Nice in 1936. No lightcurve parameters had been previously reported (Warner *et al.*, 2010a). We collected 264 images during the four nights of 2010 September 11-14 through a C filter with *Maxim DL* acquisition software. Exposures were 120 s. The CCD camera was operated at -6º C to -10º C and all images were calibrated with master bias, dark, and flat frames. According to *Astrometrica* (Raab, 2010), the asteroid magnitude as measured against the CMC-14 catalogue in R band was 14.2-14.8.



On September 11 it became evident that the two minima were very deep. We performed differential photometry of the asteroid with *Fotodif* as the images were being downloaded. This routine makes it easier to follow the asteroid lightcurve in real time. Data points obtained during the first night also showed a very rapid period and, after four sessions, we derived a lightcurve with *Canopus* that showed a period of P = 3.837 h ± 0.001 h and amplitude A = 1.05 mag.

1996 Adams. Also a main-belt asteroid, 1996 Adams was discovered at Goethe Link Observatory in 1961 under the Indiana Asteroid Program. It was chosen from the list of photometry opportunities by Warner *et al*. (2010b) in order to confirm the previously determined period of 3.56 h by Alvarez-Candal *et al*. (2004). We captured 189 images of 150-second integration time with the same setup as described above on the nights of 2010 October 1, 5 and 6. At the time, the asteroid magnitude was 13.8-14.1 as measured by *Astrometrica* against the CMC-14 catalogue in R band. The resulting lightcurve produced with *MPO Canopus* shows a synodic period of P = 3.311 ± 0.001 h with an amplitude of A = 0.42 mag. The period is significantly shorter than the one found by Alvarez-Candal *et al.* but in agreement with the one found by Durkee (this issue p. 40).



Acknowledgements

Special thanks are due to Ramón Bosque, a member of the Grup d'Astronomia de Tiana (G.A.T.) as the author, for revising this paper. I am also grateful to Julio Castellano, a successful comet observer, for his contribution with free software tools for the astronomical community. The Grup d'Astronomia de Tiana (G.A.T.) granted access to *MPO Canopus* so that we could derive the lightcurves appearing in this paper.

References

Castellano, J. Fotodif, Focas II, Orbitas. *http://www.astrosurf.com/ cometas-obs/*

JPL HORIZONS Ephemeris System: *http://ssd.jpl.nasa.gov/?ephemerides*

Raab, H. (2010). *Astrometrica* software. *http://www.astrometrica.at/*

USNO A-2.0 catalogue: *http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/icas*

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

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

Warner, B.D., Harris A. W., Pravec, P., Durech J., and Benner L. A.M. (2010a). "Lightcurve Photometry Opportunities: July - September 2010." *Minor Planet Bulletin* **37**, 130-133.

Warner, B.D., Harris A. W., Pravec, P., Durech J., and Benner L. A.M. (2010b). "Lightcurve Photometry Opportunities: October - December 2010." *Minor Planet Bulletin* **37**, 169-172.

LIGHTUCURVE ANALYSIS OF (15822) 1994 TV15: A POSSIBLE HUNGARIA BINARY

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

Donald P. Pray
Carbuncle Hill Observatory
W. Brookfield, MA USA

(Received: 13 October)

CCD observations of the Hungaria asteroid (15822) 1994 TV15 were made at the Palmer Divide Observatory (PDO) and Carbuncle Hill Observatory (CHO) in 2010 June/July. Observations on three nights indicated the possibility of mutual events (occultations or eclipses) due to a satellite. However, conclusive evidence was never obtained.

As part of the on-going program on Hungaria asteroids at the Palmer Divide Observatory (PDO), CCD observations of (15822) 1994 TV15 were obtained starting in 2010 mid-June. These were a follow-up to those obtained at PDO in 2007, when a period of 2.9597 h was found (Warner, 2007). No indications were seen at that time that the object was binary. The data from June 22 appeared to show an attenuation that was similar to those observed due to an occultation/eclipse event involving a satellite. As a result, the campaign was extended and help from Carbuncle Hill Observatory was obtained.

In all, three possible events were observed. Assuming they were due to a satellite, subsequent analysis showed a primary period of P_1 = 2.9603 ± 0.0003 h with an amplitude of 0.28 mag. The period was in good agreement with that found in 2007. An orbital period of P_{orb} = 37.19 ± 0.02 h was found. Due to the asteroid being at or fainter than 17th magnitude, getting data of sufficient precision was difficult to start and more so as the campaign continued. Eventually, we had to stop without having sufficient data to confirm the true nature of the system. It is a strong binary candidate that needs high-precision observations at subsequent apparitions.

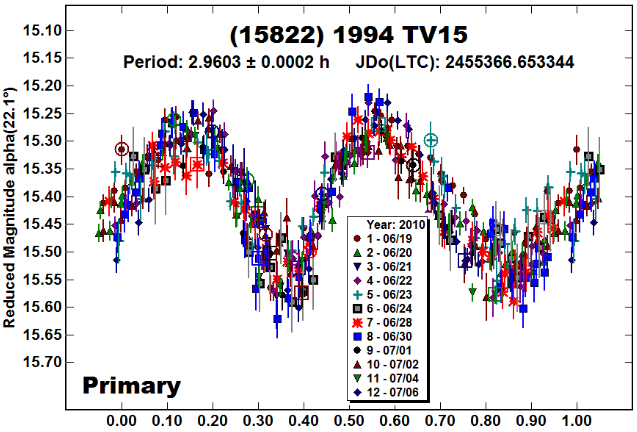
Acknowledgements

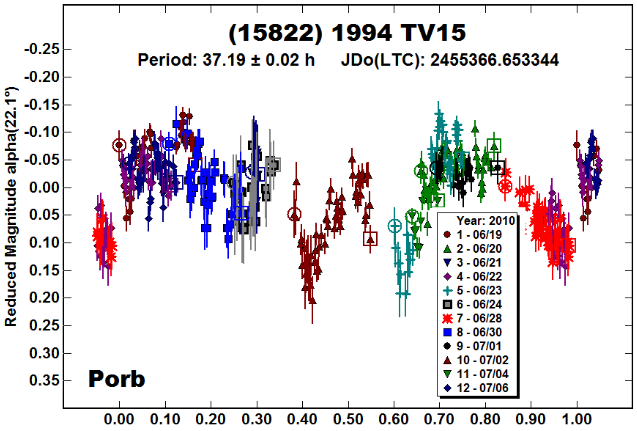
Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNX10AL35G, by National Science Foundation grant AST-1032896, and by a 2007 Gene Shoemaker NEO Grant from the Planetary Society. Partial funding for work at

Carbuncle Hill Observatory was provided by a Gene Shoemaker NEO Grant from the Planetary Society.

References

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





LIGHTCURVES AND PERIODS OF EIGHTEEN NEAS AND MBAS

Albino Carbognani
Astronomical Observatory of the Autonomous Region of the Aosta Valley (OAVdA), Nus, (Aosta) ITALY

(Received: 15 October)

Eighteen asteroids, NEAs and MBAs, were observed and lightcurves measured at OAVdA from 2009 January through 2010 September: 869 Mellena, 1643 Brown, 2983 Poltava, 3387 Greenberg, 3833 Calingasta, 3870 Mayre, 4223 Shikoku, 4391 Balodis, 4928 Vermeer, 11277 Ballard, 13009 Voloshchuk, (14691) 2000 AK119, 14815 Rutberg, (19261) 1995 MB, (68350) 2001 MK3, (162900) 2001 HG31, 2009 FD and 2009 NH.

This paper features the results of photometric observations on asteroids, both main-belt asteroids (MBAs) and near-Earth asteroids (NEAs), made at the Astronomical Observatory of the Autonomous Region of the Aosta Valley (OAVdA) (Carbognani and Calcidese, 2007), from 2009 January through to 2010 September. The data are helpful to increase the number of asteroid rotation periods to have a comprehensive statistical picture of the rotational evolution of these bodies (Carbognani, 2010a; 2010b).

The images were captured by means of a Ritchey-Cretien 0.81-m telescope operating at f/7.9. The CCD cameras used were a FLI P1001E (1024×1024 pixel, field of view of 13.2′×13.2′ and an image scale of 1.5″/pixel) or a FLI PL 3041-1-BB (2048×2048 pixel, a field of view of 16.5′×16.5′ and an image scale of 0.97″/pixel). Unless otherwise indicated, the CCD camera used for the observations is the latter.

We used MPO Canopus (Warner, 2009), version 9.5.0.14, for the differential photometry and the period analysis. In some cases, i.e. when the periods are long, the relative positions of the lightcurves, from the different sessions for the same asteroid, are determined by measuring the magnitude of the first point of the lightcurve in R band (the magnitudes are from the r′ values of the CMC14 catalog, see Miles and Dymock, 2009) and by setting the DeltaComp values in Canopus so that the lightcurves shift is the same as the R magnitude shift. To calculate the magnitude of the asteroid, we used 5 comparison stars, manually selected. In the case of very different phase angles, the magnitude has been corrected by taking the H value from JPL Small-Body Database Browser (JPL, 2010), and putting G = 0.15, the mean value between C and S-type asteroids (Shevchenko and Lupishko, 1998). With this method (hereafter, called "R shift method"), the relative lightcurves location is accurate within few hundredths of magnitude.

The amplitude of the lightcurve is obtained as the difference between maximum and minimum of a polynomial interpolation of twelfth-twentieth degree (the degree varies depending on the lightcurve complexity). The amplitude uncertainty is the standard deviation of the observed magnitude points, taking as average the value provided by the polynomial interpolating the entire lightcurve calculated at the same phase, i.e.:

$$\sigma = \sqrt{\frac{\Sigma_i^N \left(m_i - p_i\right)}{N-1}} \qquad (1)$$

In Eq. (1) N is the number of points in the lightcurve, m_i is the magnitude of the i-th point and p_i is the magnitude of the i-th point given by the polynomial fit. Thus, we obtain a representative value of the uncertainty of the entire lightcurve. Table I shows the period and the amplitude results, both with their uncertainties.

The data for the known periods were drawn from Asteroid LightCurve Data Base (or ALCDB, version of 2010 May 21), care of Alan W. Harris and Brian D. Warner of Space Science Institute and Petr Pravec of the Astronomical Institute, Czech Republic (Warner et al., 2009)

869 Mellena is an MBA. A total of 210 images were taken on 4 nights in R and V band. The observations were made in the presence of a full Moon and a hazy sky but the lightcurve coverage is complete. From the data we extracted a rotation period of 6.515 ± 0.001 hours and an amplitude of 0.26 ± 0.03 mag. Following the same procedure as was used with 2009 NH, the V-R color index is 0.24 ± 0.03 (mean of 3 values), compatible with a C-type asteroid. For this object, no period was already known.

1643 Brown is an MBA. A total of 92 images were taken on 2 nights in R band. From the data we extracted a rotation period of 5.9310 ±_0.0005 hours and an amplitude of 0.50 ± 0.02 mag. The coverage is complete. No period was already known.

2983 Poltava is a MBA. A total of 61 images were taken on 2 nights in R band. From the data we estimated a rotation period of 8.865 ±_0.003 hours and an amplitude of 0.67 ± 0.02 mag. The relative positions of the lightcurves were determined with the R shift method with correction for the phase angle difference. The coverage is complete, no period was already known.

3387 Greenberg is an MBA. A total of 55 images were taken in 3 nights in R band. From the data we extracted a rotation period of 2.6940 ± 0.0005 hours, the shortest value in the entire survey, and an amplitude of 0.18 ± 0.02 mag. The lightcurve is complex and the coverage is complete. No period was already known.

3833 Calingasta is an MBA. A total of 204 images were taken on 4 nights in R band. In the first two sessions, the sky was cloudy with a full Moon and the lightcurves are noisy while, in the last two sessions, the sky was clear. From the data we extracted a possible rotation period of 38.61 ± 0.05 hours and an amplitude of 0.49 ± 0.01 mag but the coverage is far from complete. The relative positions of the lightcurves were established with the R shift method with correction for the phase angles difference. No period was already known.

3870 Mayre is an MBA. A total of 210 images were taken on 4 nights in R and V band. The conditions of observation were similar to those for Mellena and the lightcurve coverage is complete. From the data we extracted a rotation period of 3.9915 ± 0.0001 hours and an amplitude of 0.44 ± 0.03 mag. The V-R color index is 0.45 ± 0.04 (mean of 3 values), compatible with a M-type asteroid. As for the above objects, for this no period was already known.

4223 Shikoku is an MBA. A total of 139 images were taken on 5 nights in R band. For the sessions of September 9 and 10 the comparison stars are the same. A rotation period of 9.138 ± 0.001 hours and an amplitude of 0.18 ± 0.02 mag. were extracted from the data. The coverage is complete. The points scattered between the phase 0.8 and 0.9 can be attributed to non-optimal conditions. No period was already known.

4391 Balodis is an MBA. A total of 127 images were taken on 4 nights in R band. In the first two sessions, the sky was very cloudy and the lightcurves are noisy but the coverage is complete. The third session is the best, whereas the fourth is useless, because of poor vision. A rotation period of 3.448 ± 0.001 hours and an amplitude of 0.29 ± 0.03 mag. were extracted from the data of sessions 2 and 3. No period was already known.

4928 Vermeer is a MBA. A total of 57 images were taken on 2 nights in R band. From the data we extracted a rotation period of 3.687 ±_0.001 hours and an amplitude of 0.68 ± 0.02 mag. The coverage is complete. No period was already known. Due to its short rotation period and to the two long observation sessions (easily stackable manually), this asteroid was used as a test for the R shift method validity.

11277 Ballard is an MBA. A total of 49 images were taken on 2 nights in R band. From the data available we can assume that the rotation period is greater than 10 hours and that the amplitude is greater than 0.30 mag. The relative positions of the lightcurves were determined with the R shift method. No period was already known.

13009 Voloshchuk is an MBA. A total of 226 images were taken on 6 nights. A rotation period of 14.8212 ± 0.0008 hours and an amplitude of 0.67 ± 0.03 mag. were extracted from the data. For some sessions, the relative positions of some lightcurves were determined with the R shift method. No period was already known.

(14691) 2000 AK119 is an MBA. A total of 69 images were taken in 3 nights in R band and the coverage is complete. From the data we extracted a rotation period of 3.6524 ± 0.0002 hours and an amplitude of 0.73 ± 0.02 mag., the coverage is complete. The lightcurve appear to have a textbook shape, with two maximums and two minimums of equal intensity. For this object no period was already known.

14815 Rutberg is an MBA. A total of 69 images were taken on 2 nights in R band but the coverage is far from complete and the first session is very noisy due to hazy sky together with a full Moon. The rotation period appears greater than 10 hours with an amplitude greater than 0.50 mag. The relative positions of the lightcurves were determined with the R shift method with phase angle correction. For this asteroid no period was already known.

(19261) 1995 MB is an MBA. A total of 71 images were taken on 2 nights in R band. From the data we extracted a rotation period of 4.586 ±_0.004 hours and an amplitude of 0.54 ± 0.03 mag. The coverage is complete. As for 14691, the asteroid's shape appears quite symmetrical. No period was already known.

(68350) 2001 MK3 is an Amor object. A total of 163 images were taken on 2 nights (the second session, for technical reasons, is divided into two subsections) with a C filter and an FLI 1001E CCD camera. The coverage is complete. The first session is a bit noisy but relevant to determine the rotation period. From the data we extracted a rotation period of 3.273 ± 0.001 hours and an amplitude of 0.20 ± 0.02 mag. The period and amplitude in ALCDB for this object are 3.24 h and 0.20 with U=2. No lightcurve of this object had been published before.

(162900) 2001 HG31 is an Amor object. A total of 120 images were taken on 1 night in R band with an FLI 1001E CCD camera. Being the collected data limited, it was not possible to establish a rotation period but only a lower limit for the amplitude of about 0.60 mag. due to a sudden drop in brightness. The period and amplitude in ALCDB for this object are 60.61 h and 0.56 with U=3. This is a tumbling asteroid.

2009 FD is an Apollo asteroid. A total of 348 images with a C (clear) filter were taken on 2 consecutive nights with FLI 1001E CCD camera. The data are rather noisy due to the low magnitude of the target (about +16.7) and the lightcurve coverage is not complete. From the data we extracted a rotation period, rather approximate, of 5.87 ± 0.02 hours and an amplitude of 0.24 ± 0.04 mag., but the coverage is not complete. The period and amplitude in ALCDB for the object are 4.0 h and 0.35 with U=2,which is not too different from our values.

2009 NH is an Amor asteroid. A total of 533 images were taken on 2 nights, with C, V and R filters. The lightcurve coverage is complete. From the data we extracted a rotation period of 3.033 ± 0.002 hours and an amplitude of 0.13 ± 0.014 mag. The asteroid was observed in V and R band, which made it possible to us to estimate the mean V-R color index. To this purpose, we used CMC14 catalogue and Richard Miles and Roger Dymock 's method (Miles and Dymock, 2009). The result is V-R = 0.37 ± 0.05 (the mean of 3 values). The individual color indices are essentially independent of the rotational phase, because they were corrected with the synodic period which was found. This V-R value is typical of a C-type asteroid (Shevchenko and Lupishko, 1998). For this object, no period was already known.

H_R, G and diameter estimate for 13009 Voloshchuk

In the case of asteroid 13009 Voloshchuk there are sufficient values of R magnitude (Miles and Dymock, 2009), taken at very different phase angles, for a fit in the H_R-G parameter space (see Table II). The fit gives the following results: $H_R = 12.90 \pm 0.09$ mag., $G = 0.03 \pm 0.09$ (see Fig. 19). This low G value is typical of a C-type asteroid or similar (Shevchenko and Lupishko, 1998).

If we consider that the mean V-R value for this asteroid type is 0.38 ± 0.05 mag., we can estimate the absolute magnitude in the visual band as $H_V = 13.3 \pm 0.1$. Assuming the typical p_V value for C-type (0.06 ± 0.02) we can finally estimate the actual diameter of 13009 Voloshchuk as $D = 12 \pm 2$ km.

Acknowledgments

Research on asteroids at OAVdA Observatory is supported by Director, Prof. Enzo Bertolini, and funded with a European Social Fund grant from the Regional Government of the Regione Autonoma della Valle d'Aosta (Italy). This research has made use of the SIMBAD and VIZIER databases with Aladin Sky Atlas that operate at CDS (Strasbourg, France) and of the NASA's Astrophysics Data System.

References

Carbognani, A. (2010a). "Statistical analysis of C and S Main Belt Asteroids." *Icarus* **205**, 497-504.

Carbognani, A. (2010b). "A possible YORP effect on C and S Main Belt Asteroids." DOI: 10.1016/j.icarus.2010.09.007.

Carbognani, A. and Calcidese, P. (2007). "Lightcurve and rotational period of asteroids 1456 Saldanha, 2294 Andronikov and 2006 NM." *Minor Planet Bullettin*, **34**, 18-19.

Dymock, R. and Miles, R. (2009). "A method for determining the V magnitude of asteroids from CCD images". *J. Br. Astron. Assoc.* **119**, 149-156.

Shevchenko V. G. and Lupishko D. F. (1998). "Optical properties of Asteroids from Photometric Data." *Solar System Research*, **32**, 220-232.

JPL, 2010. http://ssd.jpl.nasa.gov/sbdb.cgi

Warner, B.D., Harris, A.W, and Pravec, P. (2009). "The asteroid lightcurve database." *Icarus*, **202**, 134-146.

Warner, B.D. (2009). MPO Software, Canopus. Bdw Publishing, http://minorplanetobserver.com/.

Number	**Dates** **yyyy mm dd**	**Phase** **[deg]**	**Period** **[h]**	**Amp** **[mag]**
869	2010 06 24/25 2010 07 05/06	11.0-15.6	6.515 ± 0.001	0.26 ± 0.03
1643	2010 09 21/28	6.1-3.6	5.9310 ± 0.0005	0.50 ± 0.02
2983	2010 09 19/28	3.0-6.1	8.865 ± 0.003	0.67 ± 0.02
3387	2010 09 12/13/19	13.3-15.5	2.6940 ± 0.0005	0.18 ± 0.02
3833	2010 08 24/27 2010 09 02/03	19.1-22.4	38.61 ± 0.05	0.49 ± 0.01
3870	2010 06 24/25 2010 07 05/06	13.1-17.2	3.9915 ± 0.0001	0.44 ± 0.03
4223	2010 09 09/10/13/19/22	7.7-11.9	9.138 ± 0.001	0.18 ± 0.02
4391	2010 07 09/10/15 2010 08 24	6.1-7.1 23.9	3.448 ± 0.001	0.29 ± 0.03
4928	2010 09 09/10	11.9-12.5	3.687 ± 0.001	0.68 ± 0.02
11277	2010 07 15/19	17.4-17.8	≥ 10	≥ 0.30
13009	2010 08 01/20 2010 09 09/10/13/22	10.6-17.1	14.8212 ± 0.0008	0.67 ± 0.03
14691	2010 07 19/21/24	6.6-5.7	3.6524 ± 0.0002	0.73 ± 0.02
14815	2010 07 24/30	7.7-4.9	≥ 10	≥ 0.50
19261	2010 07 09/10	5.1-5.2	4.586 ± 0.004	0.54 ± 0.03
68350	2009 01 22/29	32.4-28.7	3.273 ± 0.001	0.20 ± 0.02
162900	2009 01 22	41.0	---	≥ 0.6
2009 FD	2009 03 21/22	17.9-18.3	5.87 ± 0.02	0.24 ± 0.04
2009 NH	2009 08 21/22	8.7-8.9	3.033 ± 0.002	0.13 ± 0.014

Table I. The list of observed asteroids with the observation dates, minimum and maximum solar phase angles, derived synodic rotation periods and lightcurve amplitudes, both with their uncertainties.

Month/Day	**UT**	**R**	**α (°)**
08 20	21:04	14.84	0.61
09 09	20:16	15.61	10.97
09 10	19:39	15.37	11.47
09 22	20:00	15.91	17.09

Table II. The R magnitude values, corrected for the rotational phase with the 14.8212 h period, used for the H_R-G estimate of the asteroid (13009) Voloshchuk. The last column shows the corresponding phase angle.

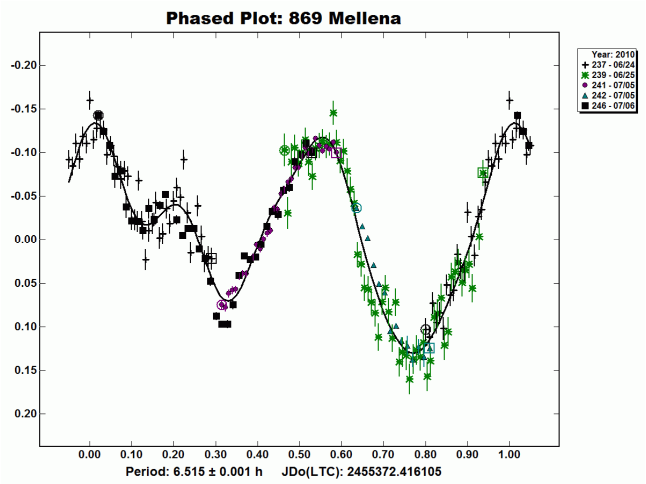


Figure 1. Full lightcurve of 869 Mellena.

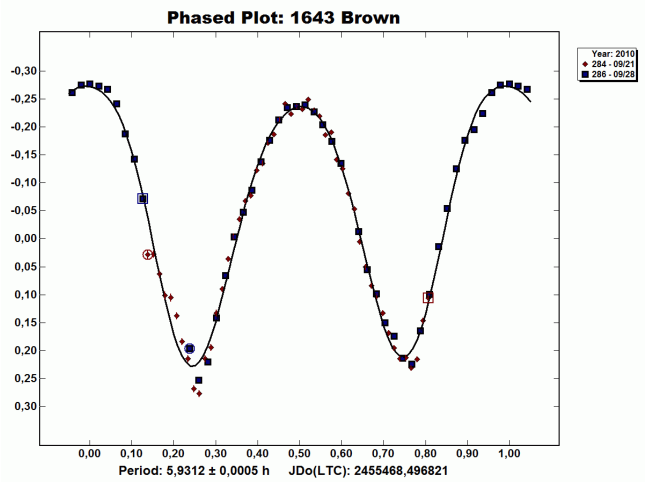


Figure 2. Full lightcurve of 1643 Brown.

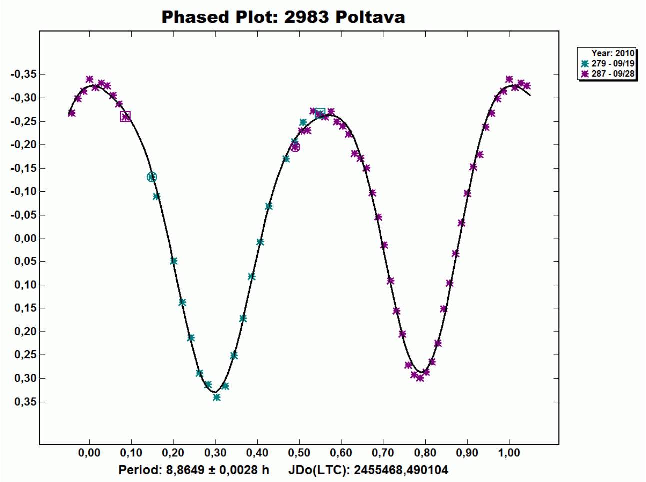


Figure 3. Full lightcurve of 2983 Poltava.

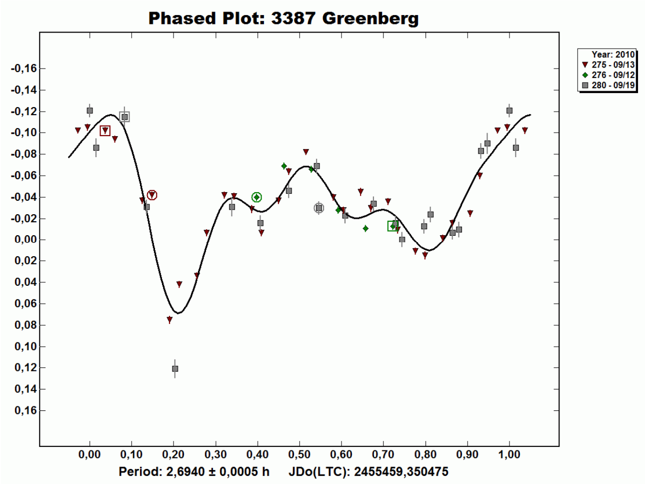


Figure 4. Full lightcurve of 3387 Greenberg.

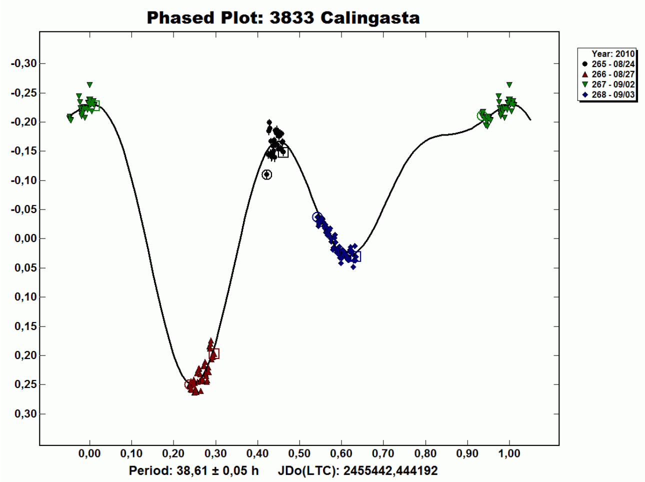


Figure 5.The partial lightcurve of 3833 Calingasta.

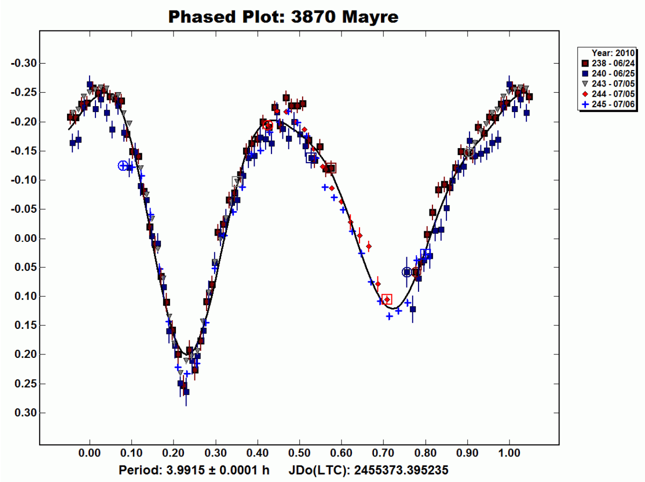


Figure 6.The full lightcurve of 3870 Mayre.

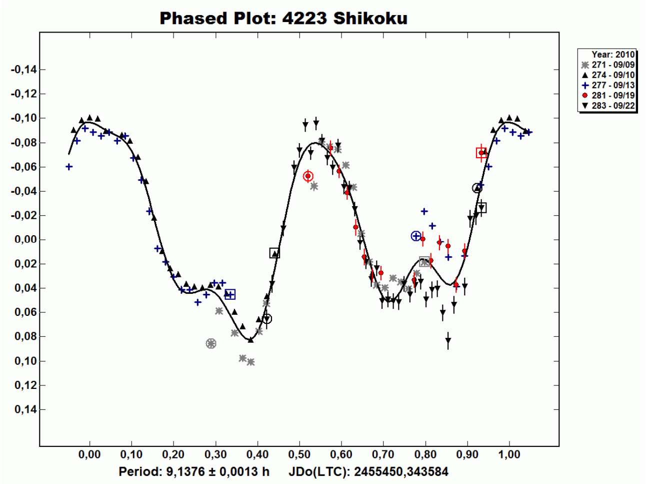


Figure 7.The full lightcurve of 4223 Shikoku.

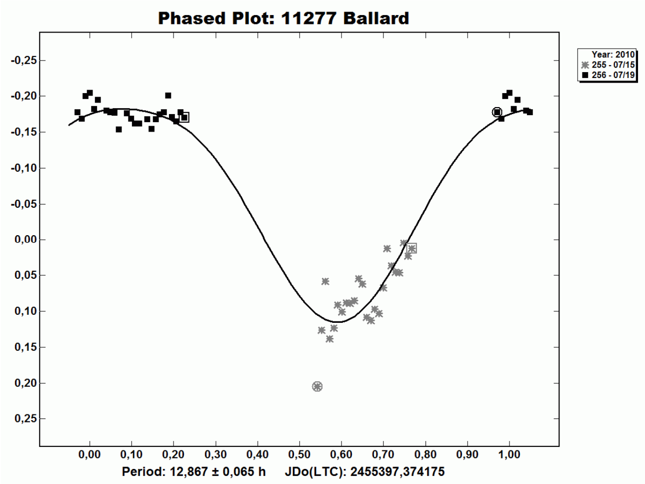


Figure 10.The partial lightcurve of 11277 Ballard.

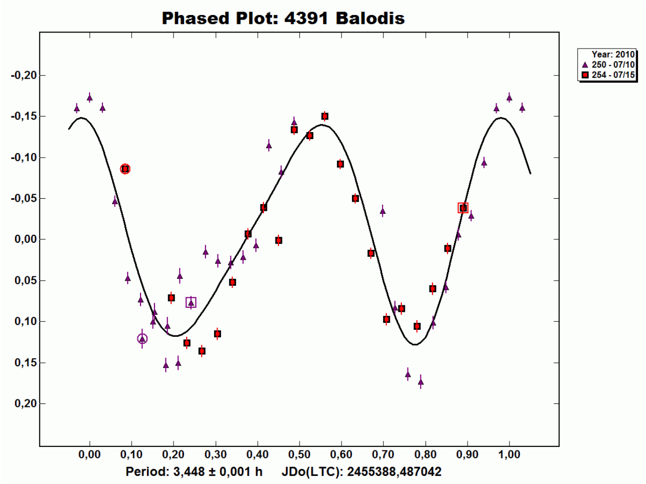


Figure 8.The full lightcurve of 4391 Balodis.

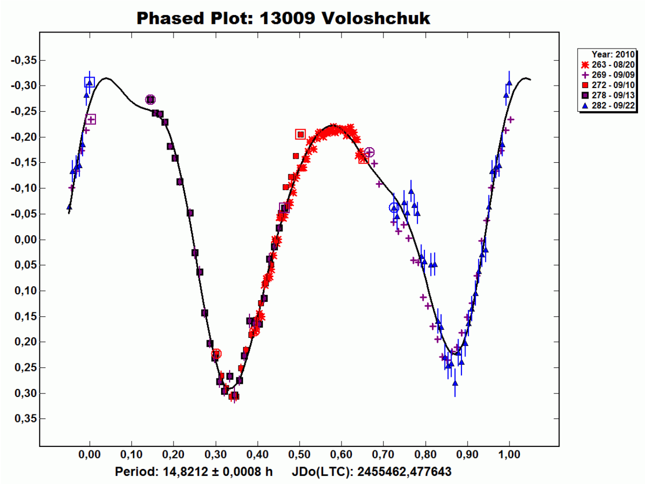


Figure 11.The full lightcurve of 13009 Voloshchuk.

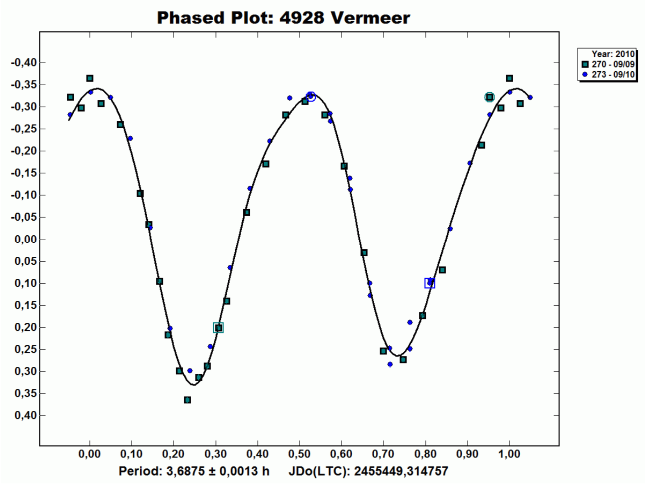


Figure 9.The full lightcurve of 4928 Vermeer.

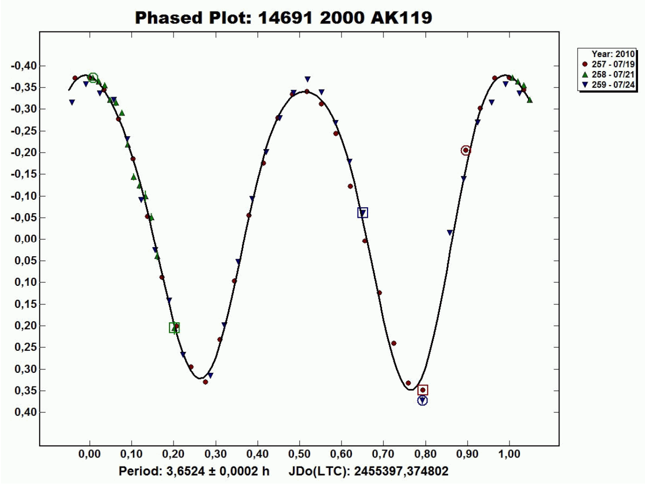


Figure 12.The full lightcurve of (14691) 2000 AK 119.

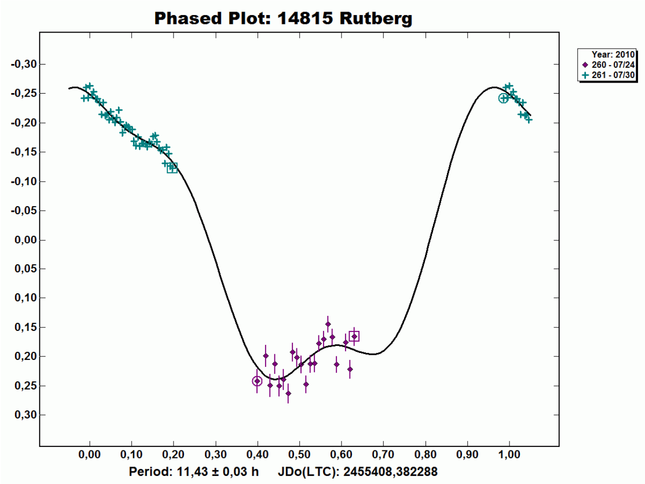


Figure 13.The partial lightcurve of 14815 Rutberg.

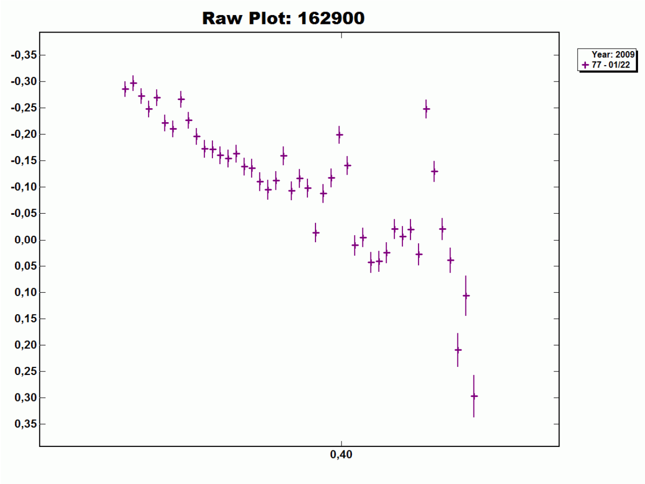


Figure 16.The partial lightcurve of (162900) 2001 HG31.

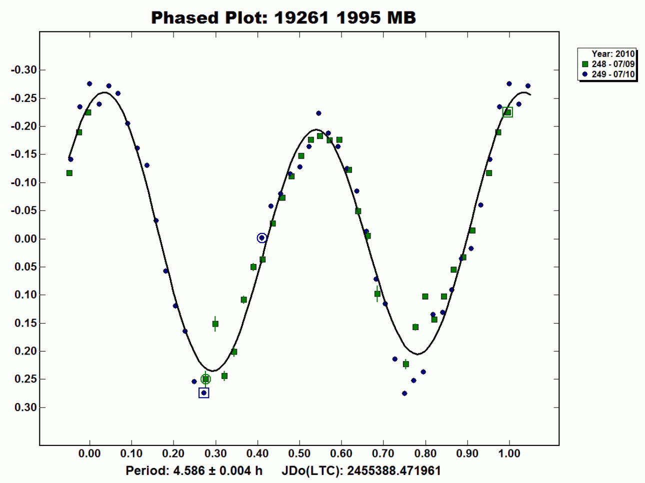


Figure 14.The full lightcurve of (19261) 1995 MB.

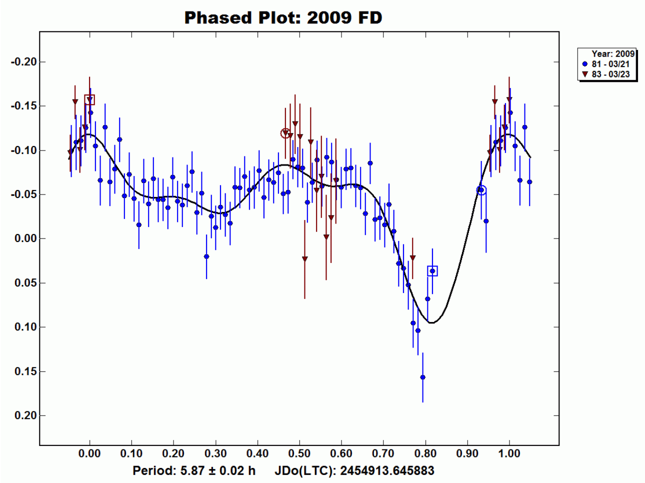


Figure 17. Partial lightcurve of 2009 FD.

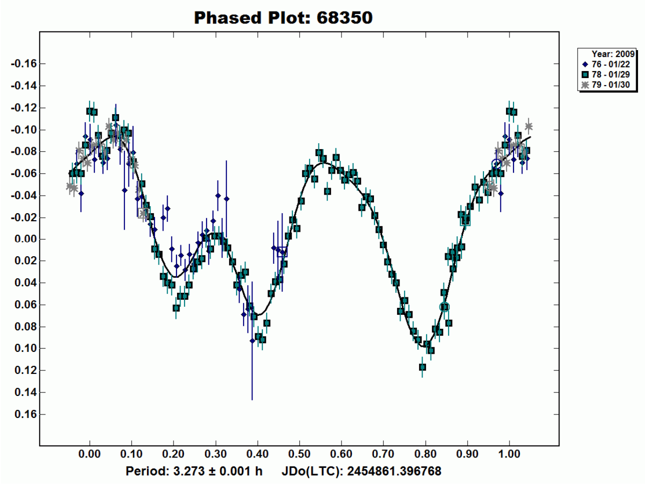


Figure 15.The full lightcurve of (68350) 2001 MK3.

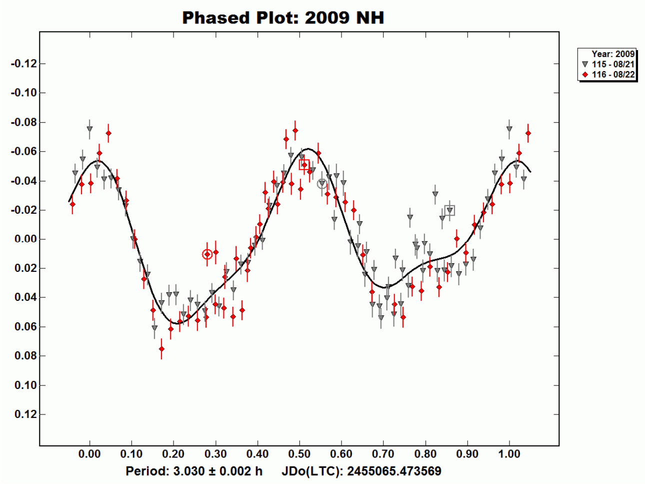


Figure 18. Full lightcurve of 2009 NH.

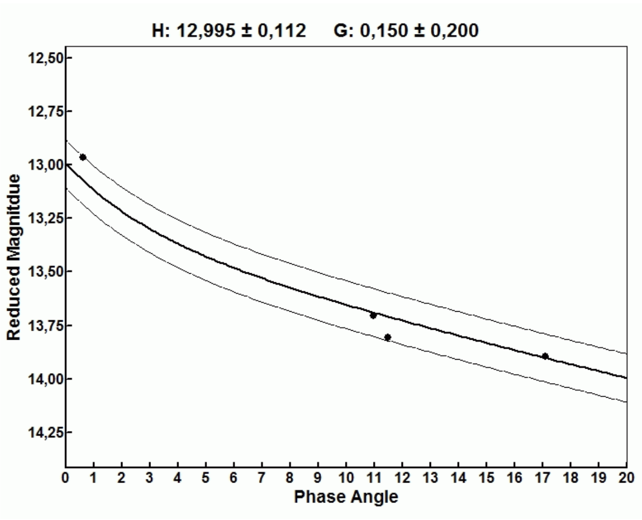


Figure 19. The H_R-G plot for 13009 Voloshchuk.

UPON FURTHER REVIEW: V. AN EXAMINATION OF PREVIOUS LIGHTCURVE ANALYSIS FROM THE PALMER DIVIDE OBSERVATORY

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

(Received: 15 October Revised: 8 November)

Updated results are given for nine asteroids previously reported from the Palmer Divide Observatory (PDO). 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 were moderately different were found for 1659 Punkajarju, 1719 Jens, 1987 Kaplan, 2105 Gudy, 2961 Katsurahama, 3285 Ruth Wolfe, 3447 Burckhalter, 7816 Hanoi, and (34817) 200` SE116. This is one 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 (ca 1999-2006). In most cases, any changes in the period and/or amplitude as a result of the new analysis were statistically insignificant. Some, however, fit into a gray area between significant and not but are still worth noting. This paper is one in a series that reports updated results from the initial stage of new analysis, in this case giving updates on six asteroids that fit into that gray area. Subsequent stages will likely produce additional revisions.

For background on the justification and methodology of this project, see the first paper in the series (Warner, 2010).

Presentation of the New Analysis

A brief analysis of the new data set and lightcurve based on that new data set are given below, 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 higher rating; see Warner et al., 2009, for information about the U code rating system). The exact observing details will not be given. Instead, a table lists 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).

1659 Punkaharju. The only change with the new analysis was a slightly larger amplitude for the 2000 apparition.

1719 Jens. The revised amplitude is slightly larger and the precision for the period has been reduced from the previous results, bringing the latter more into line with the period and span of the data set.

1987 Kaplan. The revised period is slightly shorter (0.03 h).

2105 Gudy. The period and amplitude have been revised a small amount. The U code assignment was improved.

2961 Katsurahama. The period is essentially unchanged but the amplitude increased by about 0.1 mag as a result of the new analysis.

3285 Ruth Wolfe. The original data were reanalyzed (Warner, 2005) and a new period found. The new data set allowed refining the precision of the corrected period and improved the U code assignment.

3447 Burckhalter. A new look at the original images from 2001 finds a period of 51 ± 1 h, contradicting the original analysis of 22.8 h. This latest result does not fit with the finding of Warner and Bembrick (2005), who found P = 60 h. The data used in that latter work cannot be forced to a reasonable fit with the 51 h period. This asteroid needs a dedicated campaign involving observers at widely-separated longitudes with all data linked to a common magnitude system.

7816 Hanoi. The new analysis resulted in very slight changes to the period and amplitude and an improved U code assignment.

(34817) 2001 SE116. The amplitude increased by 0.12 mag and the precision of the period decreased to reflect the period and span of the data set.

Acknowledgements

Funding for observations and research at the Palmer Divide Observatory is currently provided by NASA grant NNX 10AL35G, by National Science Foundation grant AST-1032896 and by a 2007 Gene Shoemaker NEO Grant from the Planetary Society.

		Original				Revised				
#	Name	Per	Amp	U	Ref	Per	PE	Amp	AE	U
1659	Punkaharju	5.01	0.26	3	Warner; MPB 28, 30-32	5.01	0.01	0.33	0.01	3
1719	Jens	5.867	0.50	3	Warner; MPB 28, 4-5	5.87	0.01	0.55	0.02	3
1987	Kaplan	9.49	0.46	3	Warner; MPB 28, 40-41	9.46	0.01	0.47	0.01	3
2105	Gudy	15.800	0.55	2	Warner; MPB 28, 30-32	15.795	0.003	0.52	0.01	3-
2961	Katsurahama	2.935	0.20	3	Warner; MPB 27, 20-21	2.936	0.005	0.30	0.01	3
3285	Ruth Wolfe	3.94	0.20	2	Warner; MPB 30, 61-64	3.937	0.005	0.20	0.01	3
3447	Burckhalter	22.8	>0.24	1	Warner; MPB 29, 27-28	51.	1.	0.37	0.02	2-
7816	Hanoi	5.18	0.72	2+	Warner; MPB 29, 27-28	5.17	0.01	0.77	0.02	3-
34817	2001 SE116	6.382	0.75	3	Warner; MPB 31, 19-22	6.38	0.02	0.87	0.02	3

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.

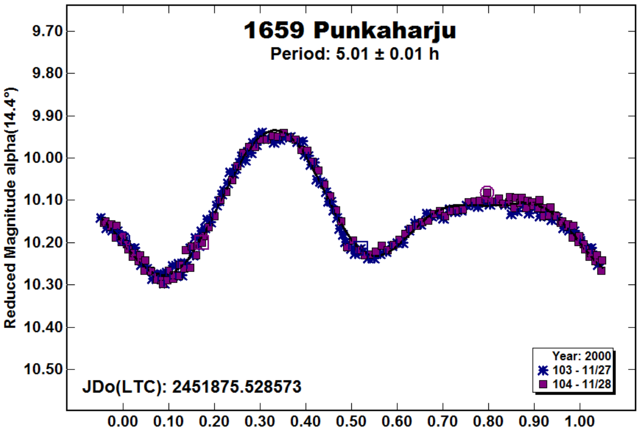
References

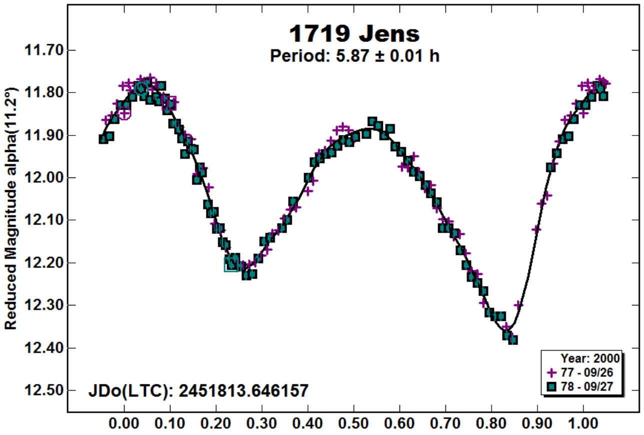
Warner, B.D. (2005). "Revised Lightcurve Analysis for 1022 Olympiada and 3285 Ruth Wolfe." *Minor Planet Bul.* **32**, 26.

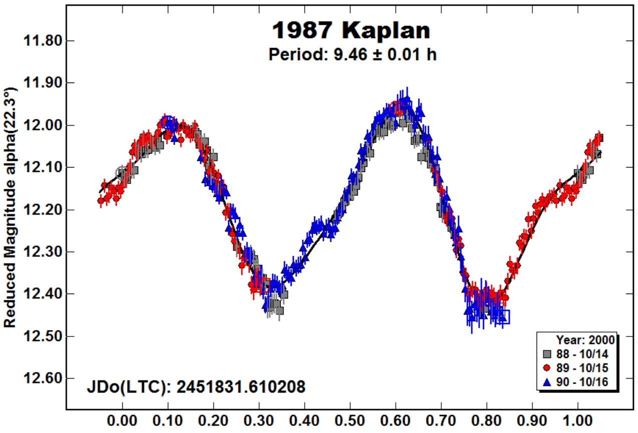
Warner, B.D. and Bembrick, C. (2005). "A Revised Period for 3447 Burckhalter." *Minor Planet Bul.* **32**, 40-41.

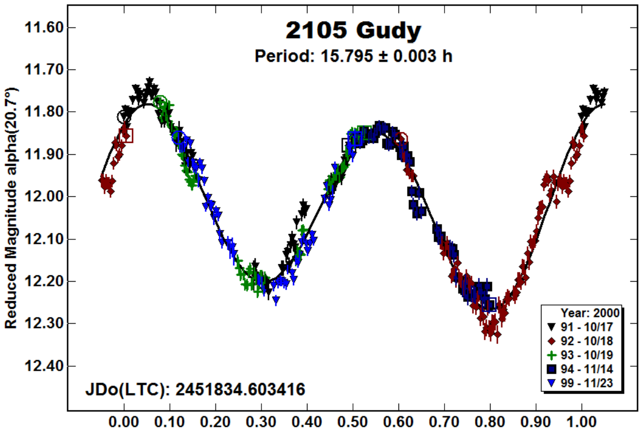
Warner, B.D., Harris, A.W., and Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146.

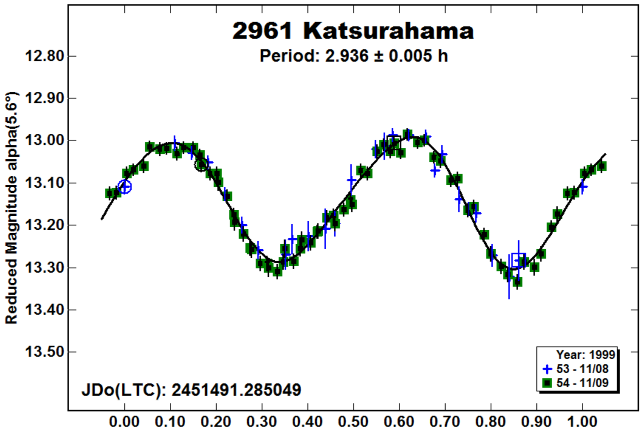
Warner, B.D. (2010). "Upon Further Review: I. An Examination of Previous Lightcurve Analysis from the Palmer Divide Observatory." *Minor Planet Bul.* 37, 127-130.

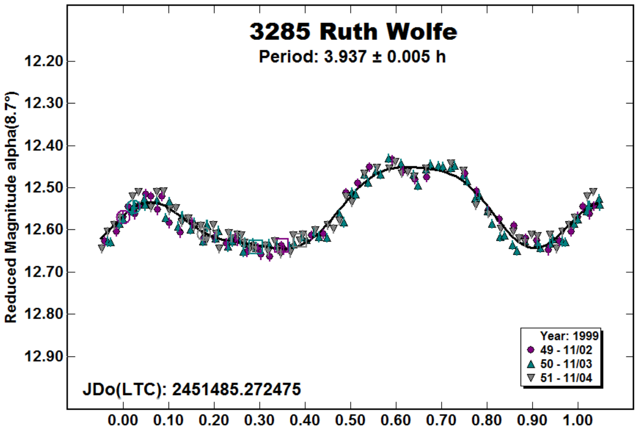


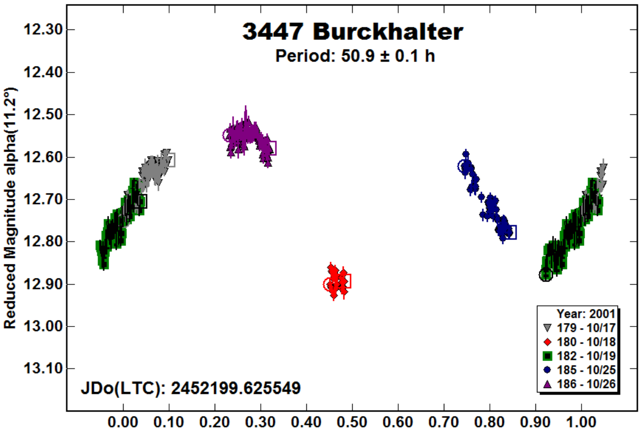


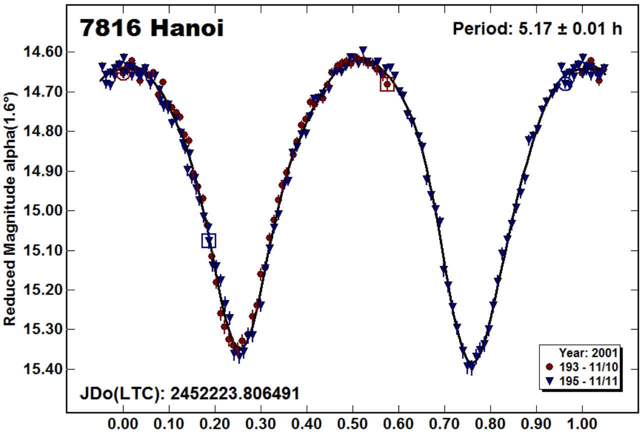


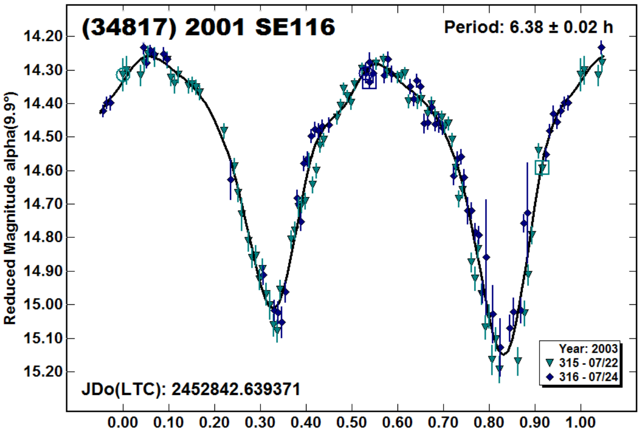












LIGHTCURVE PHOTOMETRY OPPORTUNITIES: 2011 JANUARY – MARCH

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

Alan W. Harris
MoreData!
La Canada, CA 91011-3364 USA

Petr Pravec
Astronomical Institute
CZ-25165 Ondřejov, CZECH REPUBLIC

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

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

For 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. See Lowry et al. (2007) *Science* **316**, 272-274 and Kaasalainen et al. (2007) *Nature* **446**, 420-422.

Lightcurves, new or repeats, of near-Earth asteroids (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 begin analyses of 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 2011 January-March. 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_1q_2011.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.

Funding for Warner and Harris in support of this article is provided by NASA grant NNX10AL35G and by National Science Foundation grant AST-1032896.

Lightcurve Opportunities

		Brightest				LCDB Data	
#	Name	Date	Mag	Dec	U	Period	Amp
1965	van de Kamp	1 01.6	14.4	+24			
8180	1992 PY2	1 03.4	15.0	+25	2	13.01	0.24
29515	1997 YL7	1 07.5	14.8	+32	2	12.23	0.67
1448	Lindbladia	1 08.8	14.4	+33			
4971	Hoshinohiroba	1 09.0	14.6	+23			
2843	Yeti	1 13.5	14.8	+15			
11836	Eileen	1 13.8	14.6	+ 4			
3733	Yoshitomo	1 14.1	14.5	+20			
5438	Lorre	1 15.2	13.8	+26	2	26.	0.11
99913	1997 CZ5	1 16.1	13.5	- 3	2	3.01	0.14
4452	Ullacharles	1 16.9	14.7	+32	2	9.36	0.43
3759	Piironen	1 16.7	14.4	+20			
4214	Veralynn	1 18.2	14.9	+27			
3605	Davy	1 19.0	14.6	+18	1+	2.70	0.11
1342	Brabantia	1 19.2	13.5	+33			
3252	Johnny	1 20.6	15.0	+30			
412	Elisabetha	1 21.5	12.6	+25	2	19.67	0.20
2197	Shanghai	1 22.4	15.0	+23			

Lightcurve Opportunities (cont'd)

		Brightest				LCDB Data	
#	Name	Date	Mag	Dec	U	Period	Amp
3577	Putilin	1 24.4	14.7	+17	2	29.0	0.27
52266	Van Flandern	1 24.3	14.9	+18			
280	Philia	1 25.3	14.3	+29	1	64.	0.19
862	Franzia	1 27.0	14.0	+16	2+	7.52	0.13
496	Gryphia	1 30.0	13.6	+11	1	18.0	0.05
1263	Varsavia	2 01.5	13.5	- 7	2	7.23	0.15
4930	Rephiltim	2 03.7	15.0	+21			
1721	Wells	2 05.7	14.8	+16			
5972	Harryatkinson	2 07.3	14.9	+10			
5506	1987 SV11	2 07.0	15.0	+24			
16592	1992 TM1	2 08.8	14.9	- 1			
202	Chryseis	2 14.9	11.0	+15	2	15.74	0.04-0.08
4175	Billbaum	2 17.7	14.6	+ 6			
449	Hamburga	2 17.4	11.6	+17	2+	18.26	0.08
2328	Robeson	2 17.9	14.7	+ 2	2+	18.63	0.20
2288	Karolinum	2 21.4	14.5	+32	2	42.16	0.40
5168	Jenner	2 26.5	14.2	+11			
3064	Zimmer	3 01.6	15.0	+ 8			
1261	Legia	3 08.9	14.2	+ 8	2+	8.69	0.13
5586	1990 RE6	3 09.1	14.9	+ 6			
2563	Boyarchuk	3 11.1	14.8	+ 6	2	11.04	0.11
1318	Nerina	3 13.7	13.3	+10	2	2.53	0.16
948	Jucunda	3 14.4	14.3	+ 4			
2802	Weisell	3 16.4	14.5	+12	2	37.74	0.41
1581	Abanderada	3 16.7	14.5	+ 5			
1907	Rudneva	3 17.2	14.9	+ 4	1+	44.	>0.1
856	Backlunda	3 21.7	13.3	+19	2	12.08	0.29
933	Susi	3 22.2	13.6	+ 6	1	2.06	0.08
1413	Roucarie	3 23.1	14.7	+ 0			
1183	Jutta	3 27.8	14.0	- 2			

Low Phase Angle Opportunities

#	Name	Date	α	V	Dec	Period	Amp	U
268	Adorea	01 11.1	0.22	12.2	+21	7.80	0.15-0.20	3
33	Polyhymnia	01 12.6	0.83	12.8	+24	18.601	0.14-0.21	3
1269	Rollandia	01 15.0	0.36	13.8	+20			
49	Pales	01 17.0	0.31	11.4	+20	10.42	0.18	3
150	Nuwa	01 23.6	0.98	12.6	+16	8.140	0.08-0.31	2+
517	Edith	01 23.6	0.80	13.1	+17	9.2747	0.12-0.18	3
62	Erato	01 25.3	0.12	12.7	+19	9.2213	0.12-0.15	3
283	Emma	01 27.1	0.14	13.2	+18	6.888	0.11-0.57	3
335	Roberta	01 28.1	0.95	12.8	+16	12.054	0.05-0.17	3
762	Pulcova	01 30.2	0.50	12.0	+16	5.839	0.18-0.30	3
334	Chicago	01 30.6	0.10	13.0	+18	7.361	0.15-0.67	3
569	Misa	02 04.8	0.25	12.6	+16	13.52	0.25	2
379	Huenna	02 06.2	0.37	13.8	+15	7.022	0.09	2-
44	Nysa	02 10.5	0.58	8.9	+16	6.422	0.20-0.55	3
173	Ino	02 12.2	0.67	11.7	+12	6.163	0.04-0.15	3
148	Gallia	02 13.0	0.37	11.3	+13	20.664	0.06-0.32	3
202	Chryseis	02 14.9	0.77	11.0	+15	15.74	0.04-0.08	2
125	Liberatrix	02 16.5	0.91	12.8	+10	3.968	0.20-0.71	3
830	Petropolitana	02 26.2	0.13	13.4	+09	39.0	0.15	2
592	Bathseba	03 03.3	0.51	13.4	+06	6.571	0.32	2
3	Juno	03 12.3	0.22	8.9	+04	7.210	0.13-0.22	3
615	Roswitha	03 13.1	0.63	13.6	+05	4.422	0.11	3
20	Massalia	03 14.9	0.30	8.8	+02	8.098	0.15-0.27	3
317	Roxane	03 16.0	0.47	12.9	+03	8.169	0.65	3
81	Terpsichore	03 17.5	0.32	12.6	+02	11.02	0.10	2
238	Hypatia	03 22.6	0.28	12.4	-01	8.86	0.17	3
56	Melete	03 23.5	0.91	11.8	-03	18.147	0.10-0.16	3
224	Oceana	03 27.4	0.82	11.9	-04	9.388	0.12	2
1183	Jutta	03 27.8	0.40	14.0	-02			
214	Aschera	03 29.6	0.96	12.7	-06	6.835	0.22	3

Shape/Spin Modeling Opportunities

There are two sublists here. The first is for objects for which good occultation profiles are available. These are used to constrain the models obtained from lightcurve inversion, eliminating ambiguous solutions and fixing the size of asteroid. Lightcurves are needed for modeling and/or to establish the rotation phase angle at the time the profile was obtained. The second list is of those objects for which another set of lightcurves from one more apparition will allow either an initial or a refined solution.

Occultation Profiles Available

		Brightest			Per		
#	Name	Date	Mag	Dec	(h)	Amp	U
25	Phocaea	1 01.	12.2	+03	9.927	0.03 0.18	3
78	Diana	1 01.	11.1	+36	7.2991	0.02 0.30	3
144	Vibilia	1 01.	11.5	+16	13.819	0.15	3
375	Ursula	1 01.	12.4	+44	16.83	0.17	2
386	Siegena	1 01.	11.8	-11	9.763	0.11 0.18	3
476	Hedwig	1 01.	12.2	+25	27.33	0.13	3
490	Veritas	1 01.	13.4	+05	7.930	0.33 0.58	3
498	Tokio	1 01.	12.9	+16	20.	> 0.36	1+
530	Turandot	1 01.	14.2	+16	19.947	0.10 0.16	2+
559	Nanon	1 01.	13.8	+14	10.059	0.08 0.26	3
578	Happelia	1 01.	14.2	+24	10.061	0.11 0.20	3
790	Pretoria	1 01.	13.8	+21	10.37	0.08 0.16	3
93	Minerva	1 02.0	12.2	+35	5.982	0.04 0.10	3
978	Aidamina	1 05.6	14.9	-06	10.099	0.13	2
1437	Diomedes	1 05.8	15.0	+36	24.49	0.22 0.70	3-
106	Dione	1 08.2	11.4	+27	16.26	0.08	3
404	Arsinoe	1 14.3	12.3	+29	8.887	0.27 0.38	3
49	Pales	1 17.0	11.4	+20	10.42	0.18	3
124	Alkeste	1 20.6	11.7	+16	9.921	0.08 0.15	3
791	Ani	1 26.5	14.2	+17	16.72	0.32	2
47	Aglaja	1 26.8	12.4	+24	13.178	0.02 0.17	3
334	Chicago	1 30.6	13.0	+18	7.361	0.15 0.67	3
99	Dike	2 12.3	13.2	+36	10.360	0.08 0.12	3
580	Selene	2 19.9	14.5	+15	9.47	0.27	3-
139	Juewa	3 11.7	10.3	+07	20.991	0.20	3
205	Martha	3 12.9	13.2	-06	39.8	0.10 0.50	2
324	Bamberga	3 13.8	11.7	-03	29.43	0.07 0.12	3
18	Melpomene	3 17.2	10.1	+08	11.570	0.10 0.32	3
81	Terpsichore	3 17.4	12.6	+02	10.943	0.10	3
234	Barbara	3 17.8	13.1	+13	26.468	0.19	3-
238	Hypatia	3 22.6	12.3	-01	8.86	0.17	3

Inversion Modeling Candidates

		Brightest			Per		
#	Name	Date	Mag	Dec	(h)	Amp	U
367	Amicitia	1 01.	14.2	+14	5.05	0.25 0.67	3
440	Theodora	1 01.	14.2	+22	4.828	0.43	3
510	Mabella	1 01.	14.2	+10	19.4	0.25	3
573	Recha	1 01.	14.5	+22	7.165	0.22	3
605	Juvisia	1 01.	14.5	+49	15.93	0.25	2
714	Ulula	1 01.	12.2	+08	6.998	0.48 0.63	3
1207	Ostenia	1 01.	14.8	+39	9.073	0.5 0.7	3
1503	Kuopio	1 01.	14.4	+36	9.957	0.77	3
2865	Laurel	1 01.	15.0	+39	21.5	0.15	2
706	Hirundo	1 14.6	14.2	+32	22.027	0.75 0.9	3
400	Ducrosa	1 30.2	14.6	+23	6.87	0.62	3
455	Bruchsalia	2 03.4	13.5	+30	11.838	0.12	2+
1659	Punkaharju	2 06.6	14.3	+24	5.01	0.33	3
877	Walkure	2 07.6	13.8	+18	17.44	0.33 0.40	2
1148	Rarahu	2 16.1	14.6	+13	6.544	0.94	3-
138	Tolosa	2 16.7	12.5	+17	10.101	0.18 0.45	3
1219	Britta	2 28.1	14.3	+15	5.575	0.56 0.70	3
1192	Prisma	2 28.7	14.5	+30	6.558	0.85	3
1482	Sebastiana	3 02.8	15.0	+11	10.489	0.57 0.75	3
544	Jetta	3 05.6	13.5	-02	7.745	0.44 0.52	3
1102	Pepita	3 06.1	14.4	-10	5.105	0.32 0.55	3
1333	Cevenola	3 06.6	14.8	+22	4.88	0.57 0.97	3
263	Dresda	3 06.8	14.5	+04	16.809	0.32 0.40	3
321	Florentina	3 08.4	13.8	+08	2.871	0.31 0.42	3
174	Phaedra	3 10.9	12.2	-02	5.744	0.38 0.53	3
20	Massalia	3 14.9	8.8	+02	8.098	0.15 0.27	3
317	Roxane	3 16.0	12.9	+03	8.169	0.65	3
974	Lioba	3 23.7	14.0	+07	38.7	0.37	3
1010	Marlene	3 26.3	14.8	+03	31.06	0.32	2
620	Drakonia	3 31.4	14.7	-06	5.487	0.58	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*

(137924) 2000 BD19 (2011 January, H = 19.6)

There are no known lightcurve parameters for this Nysa member asteroid. The estimated diameter is 0.9 km.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
01/20	14 01.08	+07 13.0	0.397	1.085	17.67	64.9
01/22	14 16.63	+06 09.2	0.363	1.059	17.53	68.3
01/24	14 35.11	+04 51.1	0.330	1.032	17.40	72.5
01/26	14 57.26	+03 14.7	0.300	1.004	17.31	77.7
01/28	15 23.92	+01 16.1	0.273	0.975	17.27	84.0
01/30	15 55.84	-01 07.3	0.251	0.945	17.32	91.7
02/01	16 33.32	-03 53.5	0.234	0.914	17.52	100.8
02/03	17 15.64	-06 52.3	0.225	0.882	17.92	111.0

(153201) 2000 WO107 (2011 January, H = 19.0)

There are no known lightcurve parameters for this near-Earth asteroid. The estimated diameter is 0.4 km. This is a potentially hazardous asteroid (PHA), so accurate astrometry would be useful.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
01/25	13 34.46	+28 54.5	0.227	1.084	18.35	58.4
01/27	14 00.85	+30 47.3	0.203	1.061	18.20	62.8
01/29	14 34.64	+32 39.6	0.183	1.037	18.09	68.5
01/31	15 17.58	+34 10.6	0.165	1.012	18.07	75.9
02/02	16 10.03	+34 44.6	0.153	0.987	18.18	85.0
02/04	17 08.91	+33 41.9	0.147	0.961	18.46	95.6

3554 Amun (2011 February, H = 15.9)

The period of this asteroid is 2.53 h. Given the size (2.5 km) and rotation period, it is a good candidate for being a binary, although there are no previous reports of such. Detecting a satellite by lightcurve photometry requires that it have a minimum size in relation to its parent, > 0.2 D_{primary}, and that the orbital orientation allows mutual events (occultations and eclipses). If a satellite is not tidally-locked to its orbital period, it's possible that its rotation might be seen as a second period within the data event if there are no mutual events, though the amplitude may be very small. High-precision observations are strongly encouraged.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
02/01	14 17.73	+19 21.7	0.459	1.186	16.46	53.6
02/11	14 09.66	+17 49.6	0.399	1.209	16.04	47.9
02/21	13 50.26	+15 57.3	0.340	1.226	15.49	39.7
03/03	13 14.76	+13 10.7	0.289	1.238	14.82	27.6
03/13	12 21.21	+08 45.1	0.257	1.245	14.03	11.0
03/23	11 18.97	+02 49.8	0.255	1.247	13.98	9.9
04/02	10 25.44	-02 54.3	0.282	1.243	14.76	27.0
04/12	9 49.69	-07 19.5	0.331	1.233	15.45	39.8

2003 YG118 (2011 February, H = 17.0)

The lightcurve parameters for this NEA are unknown, or at least none have been reported that we could find. The estimated size is 1.1 km.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
02/01	12 39.05	+11 36.5	0.294	1.182	16.45	42.5
02/06	13 12.57	+07 31.7	0.246	1.135	16.13	47.6
02/11	13 56.68	+01 39.6	0.208	1.090	15.89	55.4
02/16	14 54.23	-06 14.3	0.182	1.046	15.85	66.7
02/21	16 04.30	-15 04.7	0.174	1.003	16.11	80.2
02/26	17 18.38	-22 22.5	0.185	0.964	16.65	92.8

2009 FY4 (2011 February, H = 21.0)

The estimated size of this NEA is 0.18 km. There are no known lightcurve parameters. Even at its brightest, it is fainter than we usually allow. However, because of the potential for having a very short rotation period, and because of the availability of large scopes over the Internet, we include it in this quarter's list.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
02/25	4 54.86	-34 35.6	0.072	0.992	18.39	86.2
02/27	5 35.12	-23 46.8	0.067	1.003	17.92	76.9
03/01	6 11.83	-11 26.1	0.066	1.014	17.61	67.2
03/03	6 44.03	+00 34.1	0.070	1.026	17.50	59.0
03/05	7 11.63	+10 45.0	0.078	1.037	17.59	53.1
03/07	7 35.04	+18 40.9	0.089	1.047	17.79	49.6

11885 Summanus (2011 March, H = 18.6)

This NEA has no known lightcurve parameters. The estimated size is 0.5 km. As with many objects with *D* < 1 km, there is the chance that it is either a super-fast rotator or tumbling.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
03/10	4 16.18	+72 12.9	0.123	0.999	17.18	83.5
03/12	5 46.51	+69 47.2	0.114	1.010	16.85	78.4
03/14	6 59.52	+64 22.0	0.107	1.021	16.53	72.4
03/16	7 50.26	+56 38.9	0.103	1.032	16.26	65.7
03/18	8 24.64	+47 36.7	0.102	1.044	16.05	58.8
03/20	8 48.65	+38 13.4	0.105	1.056	15.94	52.4
03/22	9 06.15	+29 16.5	0.110	1.068	15.93	46.9
03/24	9 19.45	+21 15.7	0.119	1.081	16.00	42.7

(141484) 2002 DB4 (2011 March, H = 16.4)

Only those in the Southern Hemisphere need apply for this NEA. It should be within reach of medium to large backyard telescopes. There are no known lightcurve parameters for the asteroid, which is estimated to be 1.5 km in size.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
03/10	13 23.67	-72 24.2	0.318	1.097	16.45	62.8
03/15	13 25.55	-77 00.7	0.289	1.079	16.29	65.5
03/20	13 26.14	-82 18.8	0.261	1.058	16.14	69.2
03/25	13 14.17	-88 35.7	0.234	1.036	16.01	74.1
03/30	1 34.95	-83 44.9	0.209	1.011	15.94	80.6
04/04	1 33.10	-74 14.9	0.187	0.985	15.98	89.3
04/09	1 32.41	-62 27.2	0.170	0.956	16.21	100.5

(22771) 1999 CU3 (2011 March, H = 16.8)

Earlier observations by Pravec et al. found a period of 3.782 h for this 1.4 km NEA. Radar observations show a "coke bottle" shape, which supports the amplitude of nearly 1 magnitude previously reported. Lightcurve observations might help constrain the pole direction and refine shape modeling.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
03/01	10 55.14	+05 49.5	0.622	1.612	17.04	1.9
03/06	10 42.60	+05 52.4	0.586	1.577	16.96	3.4
03/11	10 28.81	+05 54.3	0.557	1.540	17.06	8.7
03/16	10 14.25	+05 54.0	0.534	1.503	17.14	14.4
03/21	9 59.45	+05 49.9	0.517	1.465	17.20	20.2
03/26	9 44.97	+05 41.2	0.506	1.427	17.27	26.0

(23187) 2000 PN9 (2011 March, H = 16.1)

Observations in 2001 and 2006 found a period of 2.53 h for this 1.8 km NEA. Normally, this would be another potential binary candidate but previous radar observations found no indications of a satellite, especially one that could be found by photometry. Accurate astrometry to refine orbit parameters will also be useful since this is a potentially hazardous asteroid (PHA).

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
03/05	2 46.46	-29 40.4	0.163	0.915	16.35	113.5
03/10	3 51.83	+01 57.3	0.118	0.956	15.25	105.0
03/15	5 16.92	+39 30.7	0.139	0.998	14.77	84.4
03/20	6 46.93	+56 55.8	0.206	1.042	15.26	71.4
03/25	8 01.31	+62 42.5	0.287	1.087	15.85	64.4
03/30	8 54.77	+64 23.1	0.373	1.133	16.37	59.8

1999 TK12 (2011 March, H = 17.9)

This 0.7 km NEA has no known lightcurve parameters. It's a bit fainter than usually allowed but we're finding many backyard astronomers are able to push limits more than in the past. We'd be interested to hear about observations with telescopes of *D* < 0.5 m.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
03/01	14 09.02	+14 07.1	0.245	1.163	17.08	40.9
03/06	13 44.90	+07 42.0	0.241	1.187	16.85	32.4
03/11	13 19.45	+01 09.1	0.244	1.212	16.66	23.6
03/16	12 54.07	-05 01.0	0.255	1.238	16.55	15.6
03/21	12 30.16	-10 22.0	0.274	1.264	16.55	10.1
03/26	12 08.83	-14 41.5	0.300	1.291	16.78	10.0

2000 EF104 (2011 March, H = 18.9)

There are no known lightcurve parameters for this NEA with an estimated size of 0.5 km. Despite its faintness, we've included it because of the potential for being a super-fast rotator.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
02/15	20 14.72	+59 46.2	0.183	0.958	18.47	94.0
02/20	19 16.09	+69 43.4	0.187	0.994	18.14	82.8
02/25	17 14.06	+76 25.7	0.197	1.031	17.97	72.5
03/02	14 21.31	+76 31.5	0.211	1.067	17.92	63.6
03/07	12 35.00	+71 30.9	0.231	1.102	17.97	56.2
03/12	11 45.54	+65 19.3	0.255	1.136	18.08	50.4
03/17	11 20.27	+59 20.2	0.283	1.170	18.25	46.1
03/22	11 06.16	+53 53.0	0.314	1.202	18.45	43.1

2004 XN50 (2011 March, H = 18.8)

This NEA has an estimated size of 0.5 km. There are no known lightcurve parameters. Those with larger backyard telescopes should be able to work it, assuming the predicted magnitude is correct.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
03/25	16 33.09	-09 49.9	0.233	1.116	17.85	54.0
03/26	16 45.37	-09 48.1	0.219	1.102	17.76	56.4
03/27	16 59.14	-09 44.1	0.207	1.088	17.68	59.1
03/28	17 14.58	-09 37.1	0.195	1.073	17.61	62.3
03/29	17 31.88	-09 26.2	0.183	1.059	17.57	65.8
03/30	17 51.20	-09 10.1	0.173	1.045	17.54	69.9
03/31	18 12.61	-08 47.8	0.165	1.030	17.55	74.5
04/01	18 36.09	-08 18.0	0.158	1.015	17.60	79.6

2005 EY169 (2011 March, H = 22.2)

There are no known lightcurve parameters for this NEA. Its estimated size is only 0.1 km. This will probably require at least a 0.5-m telescope, probably more, to work with sufficient SNR.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
03/05	12 33.33	+03 00.4	0.087	1.072	18.10	21.5
03/06	12 28.31	-00 55.9	0.083	1.070	17.96	20.4
03/07	12 22.75	-05 13.3	0.080	1.067	17.86	19.9
03/08	12 16.61	-09 50.6	0.077	1.064	17.79	20.5
03/09	12 09.81	-14 45.2	0.075	1.062	17.77	22.1
03/10	12 02.29	-19 52.7	0.074	1.059	17.80	24.7

2008 EY5 (2011 March, H = 20.1)

This NEA has an estimated size of 0.3 km and no known lightcurve parameters. It will be a difficult target due to large sky motion and faintness.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
03/05	11 25.79	-75 40.9	0.097	1.010	17.74	76.6
03/07	9 36.57	-72 46.3	0.093	1.013	17.57	74.5
03/09	8 24.28	-66 54.4	0.090	1.016	17.47	72.9
03/11	7 41.39	-59 32.1	0.090	1.017	17.43	71.9
03/13	7 14.95	-51 40.5	0.091	1.019	17.46	71.7
03/15	6 57.58	-43 58.4	0.095	1.019	17.56	72.3
03/17	6 45.51	-36 48.9	0.100	1.019	17.71	73.4
03/19	6 36.74	-30 23.3	0.107	1.018	17.90	74.9

IN THIS ISSUE

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

Number	Name	Page	EP
27	Euterpe	50	50
65	Cybele	50	50
93	Minerva	8	8
103	Hera	32	32
266	Aline	15	15
287	Nephthys	8	8
295	Theresia	5	5
296	Phaetusa	50	50
308	Polyxo	41	41
326	Tamara	41	41
369	Aeria	41	41
370	Modestia	23	23
448	Natalie	54	54
500	Selinur	5	5
504	Cora	41	41
573	Recha	52	52
575	Renate	52	52
605	Juvisia	52	52
620	Drakonia	52	52
664	Judith	11	11
665	Sabine	8	8
672	Astarte	50	50
687	Tinette	52	52
762	Pulcova	8	8
787	Moskva	52	52
822	Lalage	41	41
836	Jole	12	12
850	Altona	15	15
860	Ursina	22	22
869	Mellena	9	9
		57	57
878	Mildred	1	1
884	Priamus	2	2
938	Chlosinde	23	23
983	Gunila	52	52
996	Hilaritas	14	14
		49	49
1018	Arnolda	5	5
1027	Aesculapia	5	5
1142	Aetolia	39	39
1146	Biarmia	22	22
1158	Luda	22	22
1162	Larissa	5	5
1164	Kobolda	41	41
1211	Bressole	24	24
1258	Sicilia	5	5
1260	Walhalla	5	5
1282	Utopia	52	52
1373	Cincinnati	25	25
1375	Alfreda	5	5
1453	Fennia	46	46
1469	Linzia	31	31
1521	Seinajoki	39	39
1600	Vyssotsky	52	52
1619	Ueta	23	23
		41	41
1625	The NORC	41	41
1643	Brown	39	39
		57	57
1659	Punkaharju	63	63
1685	Toro	41	41
1719	Jens	63	63
1730	Marceline	55	55
1834	Palach	5	5
1987	Kaplan	63	63
1996	Adams	39	39
		55	55
2074	Shoemaker	33	33
2105	Gudy	63	63
2189	Zaragoza	41	41
2261	Keeler	3	3
2287	Kalmykia	41	41
2375	Radek	9	9
2501	Lohja	46	46
2577	Litva	33	33
2639	Planman	41	41
2642	Vesale	25	25
2650	Elinor	23	23
2860	Pasacentennium	25	25
2961	Katsurahama	63	63
2983	Poltava	57	57
3076	Garber	46	46
3145	Walter Adams	13	13
3285	Ruth Wolfe	63	63
3387	Greenberg	25	25
		49	49
		57	57
3431	Nakano	22	22
3447	Burckhalter	63	63
3560	Chenqian	5	5
3695	Fiala	41	41
3774	Megumi	5	5
3833	Calingasta	57	57
3870	Mayre	49	49
		57	57
3991	Basilevsky	5	5
4029	Bridges	46	46
4116	Elachi	25	25
4223	Shikoku	40	40
		57	57
4391	Balodis	57	57
4440	Tchantches	25	25
4483	Petofi	25	25
4674	Pauling	25	25
4786	Tatianina	41	41
4928	Vermeer	57	57
5175	Ables	25	25
5325	Silver	46	46
5333	Kanaya	41	41
5452	1937 NN	41	41
5968	Trauger	25	25
6087	Lupo	25	25
6139	Naomi	5	5
6163	Reimers	25	25
6170	Levasseur	41	41
6244	Okamoto	46	46
6265	1985 TW3	46	46
6838	Okuda	5	5
7087	Lewotsky	25	25
7173	Sepkoski	25	25
7741	Fedoseev	41	41
7816	Hanoi	63	63
8026	1991 JA1	33	33
8523	Bouillabaisse	18	18
9297	Marchuk	5	5
10091	Bandaisan	18	18
10179	Ishigaki	18	18
10936	1998 FN11	22	22
11058	1991 PN10	25	25
11277	Ballard	57	57
11424	1999 LZ24	22	22
11549	1992 YY	5	5
13009	Voloshchuk	57	57
14691	2000 AK119	57	57
14790	Beletskij	39	39
14815	Rutberg	41	41
		57	57
15724	Zille	41	41
15822	1994 TV15	56	56
15964	Billgray	25	25
16525	Shumarinaiko	41	41
19261	1995 MB	9	9
		57	57
20037	Duke	33	33
20038	1992 UN5	18	18
20453	1999 KL6	11	11
21688	1999 RK37	25	25
21996	1999 XP31	41	41
29729	1999 BY1	41	41
31956	Wald	18	18
33203	1998 FA57	25	25
34817	2001 SE116	63	63
35404	1997 YV5	41	41
39087	2000 VN50	41	41
45436	2000 AD176	25	25
46559	1991 PC1	25	25
47081	1998 YV9	18	18
49574	1999 CO119	18	18
49675	1999 SW27	25	25
49678	1999 TQ7	25	25
57219	2001 QY71	25	25
61907	2000 QK230	18	18
66146	1998 TU3	41	41
66193	1999 AF22	25	25
68350	2001 MK3	57	57
72693	2001 FS72	18	18
76864	2000 XR13	25	25
76929	2001 AX34	25	25
82060	2000 WX8	25	25
84944	2003 WL153	18	18
101769	1999 FF52	41	41
102063	1999 RR134	25	25
154029	2002 CY46	32	32
162900	2001 HG31	57	57
164400	2005 GN59	10	10
174633	2003 SM110	25	25
	2006 WL15	25	25
	2009 EW	36	36

Number	Name	Page	EP
	2009 FD	57	57
	2009 NH	57	57
	2009 QH34	36	36
	2009 UD	36	36
	2009 WV51	36	36
	2010 EX11	36	36
	2010 GF7	36	36

THE MINOR PLANET BULLETIN (ISSN 1052-8091) is the quarterly journal of the Minor Planets Section of the Association of Lunar and Planetary Observers (ALPO). Current and most recent issues of the *MPB* are available on line, free of charge from:
http://www.minorplanetobserver.com/mpb/default.htm.
Nonmembers are invited to join ALPO by communicating with: Matthew L. Will, A.L.P.O. Membership Secretary, P.O. Box 13456, Springfield, IL 62791-3456 (will008@attglobal.net). The Minor Planets Section is directed by its Coordinator, Prof. Frederick Pilcher, 4438 Organ Mesa Loop, Las Cruces, NM 88011 USA (pilcher@ic.edu), assisted by Lawrence Garrett, 206 River Rd., Fairfax, VT 05454 USA (LSGasteroid@msn.com). Dr. Alan W. Harris (Space Science Institute; awharris@spacescience.org), and Dr. Petr Pravec (Ondrejov Observatory; ppravec@asu.cas.cz) serve as Scientific Advisors. The Asteroid Photometry Coordinator is Brian D. Warner, Palmer Divide Observatory, 17995 Bakers Farm Rd., Colorado Springs, CO 80908 USA (brian@MinorPlanetObserver.com).

The Minor Planet Bulletin is edited by Professor Richard P. Binzel, MIT 54-410, Cambridge, MA 02139 USA (rpb@mit.edu). Brian D. Warner (address above) is Assistant Editor. The *MPB* is produced by Dr. Robert A. Werner, JPL MS 301-121, 4800 Oak Grove Drive, Pasadena, CA 91109 USA (robert.a.werner@jpl.nasa.gov) and distributed by Derald D. Nye. Direct all subscriptions, contributions, address changes, etc. to:

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

Effective with Volume 38, the *Minor Planet Bulletin* is a limited print journal, where print subscriptions are available only to libraries and major institutions for long-term archival purposes. In addition to the free electronic download of the *MPB* noted above, electronic retrieval of all *Minor Planet Bulletin* articles (back to Volume 1, Issue Number 1) is available through the Astrophysical Data System http://www.adsabs.harvard.edu/. Library and institution rates for print subscriptions (four issues) of Volume 38 are:

Payment by check: $24.00 Payment by credit card: $25.00
Outside North America: $34.00 / $35.00

For readers of the free electronic version online, a voluntary contribution of $5 or more per year is most welcome (in support of the library archives). Checks or money orders should be in US dollars, drawn on a US bank, and made payable to the "Minor Planet Bulletin." To contribute by credit card, (Visa, Mastercard, or Discover) please send by mail your credit card number, your name exactly as it appears on the card, and the expiration date. Credit card charges will be made through "Roadrunner Mkt, Corona AZ." For libraries: when sending your subscription order, be sure to include your full mailing address and an email address. The upper-right corner of your mailing label indicates the volume and issue number with which your current subscription expires.

Authors should submit their manuscripts by electronic mail (rpb@mit.edu). Author instructions and a Microsoft Word template document are available at the web page given above. All materials must arrive by the deadline for each issue. Visual photometry observations, positional observations, any type of observation not covered above, and general information requests should be sent to the Coordinator.

* * * * *

The deadline for the next issue (38-2) is January 15, 2011. The deadline for issue 38-3 is April 15, 2011.