LIGHTCURVE ANALYSIS OF ASTEROIDS 53, 698, 1016, 1523, 1950, 4608, 5080, 6170, 7760, 8213, 11271, 14257, 15350 AND 17509

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Lightcurve period and amplitude results are reported for fourteen asteroids observed at Carbuncle Hill Observatory and other sites during October 2005-May 2006. The following synodic periods and amplitudes were determined: 53 Kalypso, 18.075±0.005hr, 0.14mag; 698 Ernestina, 5.0363±0.0005hr, 0.30mag; 1016 Anitra, 5.928±0.001hr, 0.30mag; 1523 Pieksamaki, 5.3202±0.0005hr, 0.50mag; 1950 Wempe, 16.788±0.001hr, 0.98mag; 4608 Wodehouse, 13.95±0.01hr, 0.10mag; 5080 Oja, 7.2220±0.0004hr, 0.37mag; 6170 Levasseur, 2.6529±0.0003hr, 0.14mag; (7760) 1990 RW3, 25.940±0.005hr, 0.32mag; (8213) 1995 FE, 2.911±0.001hr, 0.38mag; (11271) 1988 KB, 6.326±0.001hr, 0.36mag; (14257) 2000 AR97, 13.584±0.002hr, 0.67mag; 15350 Naganuma, 2.5835±0.0001hr, 0.20mag; 17509 Ikumadan, 5.788±0.001hr, 0.40mag.

Carbuncle Hill Observatory (CHO), MPC code I00, is located about twenty miles west of Providence, RI, in one of the darkest spots in this diminutive state. Of the asteroids reported here, seven were observed exclusively at CHO, while the remaining seven involved collaborations with nine observers from five other observatories. Targets in Table I are noted to show contributors and their affiliation (Table II). Below, is a description of equipment used by collaborating observatories. Observations at CHO were made using two CCD/telescope systems housed in separate buildings. One was a SBIG ST-10XME CCD camera, binned 3x3, coupled to a 0.35m f/6.5 SCT. The other was a SBIG ST-7ME CCD camera, binned 1x1, coupled to a 0.25m f/4 Schmidt-Newtonian. These systems produced image dimensions of 21x14 arcmin (1.9 arcsec per pixel), and 23x16 arcmin (1.8 arcsec per pixel), respectively. All observations were taken through the “clear” filter. Hunters Hill Observatory is equipped as described in Higgins (2005). All observations for this paper were made using a Clear filter with guided exposure times ranging from 180 seconds to 240 seconds. Modra Observatory used a 0.6m, f/5.5 reflector with AP8p CCD camera. Image dimensions were 25 arcmin squared (1.5 arcsec per pixel). All images were taken through the “clear” filter. Ondrejov Observatory used a 0.65m, f/3.6, reflector with an Apogee AP7p CCD at the prime focus, and an R filter designed to closely match the Cousins system. The image dimensions were 18x18 arcminutes. Skalnaté Pleso Observatory used a 0.65-m f/4.2 Newtonian reflector and a SBIG ST-8XME CCD camera. Frames were binned 2x2 (1.4 arcsec per pixel). The system produced image dimensions of 19x13 arcminutes. Differential photometry was performed through a Johnson-Cousins R filter. Sonoita Observatory used a 0.35m SCT (C-14), at f/11, and imaged with a clear filter, using 5 minute, unguided exposures.

All but three of the targets were selected from a list provided by Pravec (2006) as part of his “Photometric Survey of Asynchronous Binary Asteroids” study. Two asteroids, 53 and 1016, were selected from the “CALL” website’s “List of Potential Lightcurve Targets” (Warner 2006). The remaining object, 698, was selected from a list of control group objects compiled for a study of the Koronis family of asteroids being carried out by Slivan (2006). At CHO, image calibration via dark frames, bias frames and flat field frames was performed using *“MaxIm DL”*. Lightcurve construction and analysis was accomplished using “*Canopus*” developed by Brian Warner. Differential photometry was used in all cases, and all measurements were corrected for light travel time.

Results are shown in Table I. Column headings are self-explanatory. Plots of the lightcurves are also shown. Five of the asteroids, 53, 698, 1016, 1523 and 5080, had been previously studied by other observers, as noted below.

53 Kalypso. This asteroid had been found, photoelectrically, to have a rotational period of 17. hours (Harris and Young, 1989). This is reasonably close to the current determination of 18.075hr, particularly considering that the Harris and Young value came from a single night’s data.

698 Ernestina. This asteroid was found, in January, 2002, to have a period of 5.033±0.003hr and a lightcurve amplitude 0.71mag (Behrend, 2006). The currently determined period of 5.0363±0.0005hr agrees well with this. However, the Behrend amplitude value is more than twice the 0.30mag value found here. The reason for this is unknown, although it’s likely caused by changes in the viewing geometry.

1016 Anitra. Menke (2005) determined the period and amplitude of this to be 5.9300±0.0003hr, and 0.30mag respectively from data collected in 2002 and 2003. These agree very closely with parameters currently presented.

1523 Pieksamaki. Lagerkvist (1979) found a period of 5.328hr, and an amplitude of ~0.5mag. These values were derived from photographic plates taken on two successive nights. The lightcurve parameters found in the current paper agree closely with those.

#	Name	Observation Date Range	Sessions	Images	Period (h)	PE (h)	Amplitude (m)	Phase angle Range	LPAB Range	BPAB Range
53	Kalypso (7)	03/01-03/17, 2006	7	145	18.075	0.005	0.14	17.1-22	128.4-131.2	(-.08)-(-0.1
698	Ernestina (7)	10/22-10/31, 2005	3	140	5.0363	0.0005	0.30	3.4-0.5	36.8-36.7	(-1.5)-(-1.0
1016	Anitra (7)	10/01-10/20, 2005	5	186	5.928	0.001	0.30	0.9-10.5	9.3-10.3	0-1.0
1523	Pieksamaki (7)	12/22-12/28, 2005	5	334	5.3202	0.0005	0.50	11.7-8.6	109.4-109.8	5.0-4.9
1950	Wempe (2,5,7,8)	12/10-01/10, 2006	7	357	16.788	0.001	0.98	24.2-11.3	122.0-126.7	3.5-4.7
4608	Wodehouse (5,8,	12/3-12/9, 2005	6	394	13.95	0.01	0.10	7.1-6.4	75.7-76.1	(-8.9)-(-9.1
5080	Oja (1,5,7)	12/31-01/10, 2006	3	218	7.2220	0.0004	0.37	7.7-4.2	109.1-109.6	6.8-6.6
6170	Levasseur (4,7)	12/3-12/7, 2005	5	191	2.6529	0.0003	0.14	27.1-26.9	88.3-89.3	33.2-33.9
7760	1990 RW3 (1,2,7)	10/02-10/31, 2005	12	261	25.940	0.005	0.32	1.1-15.2	9.6-12.3	(-1.4)-(0.9)
8213	1995 FE (5,7)	03/18-03/21, 2006	4	78	2.911	0.001	0.38	9.1-4.5	176.8-177.2	9.2-6.0
11271	1988 KB (6,7)	05/01-05/03, 2006	2	184	6.361	0.001	0.36	20.9-20.5	230.1-230.3	27.8-27.5
14257	2000 AR97 (7)	10/22-11/03, 2005	5	260	13.584	0.002	0.67	2.4-7.5	29.0-29.8	(-3.5)-(-2.9
15350	Naganuma (3,7)	11/3-11/20, 2005	17	922	2.5835	0.0001	0.20	3.1-10.1	42.9-45.5	(-3.1)-(-4.0
17509	Ikumadan (7)	04/16-04/22, 2006	4	236	5.788	0.001	0.40	13.6-16.1	194.5-195.5	13.2-13.2

Table I. Summary of Results

5080 Oja. Previously determined parameters of P=7.68hr and A=0.31mag are reported by Lagerkvist (1978). The current values presented here, P=7.222hr, and A=0.39mag are refinements to this. The Lagerkvist data was obtained using photographic plates.

Acknowledgements

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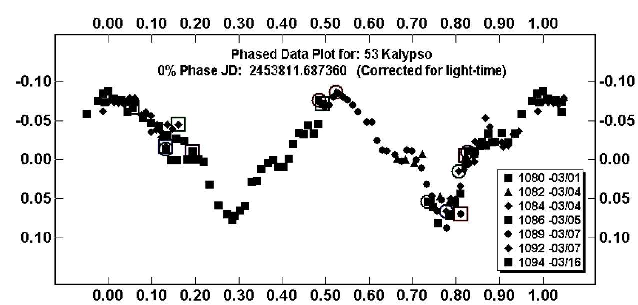
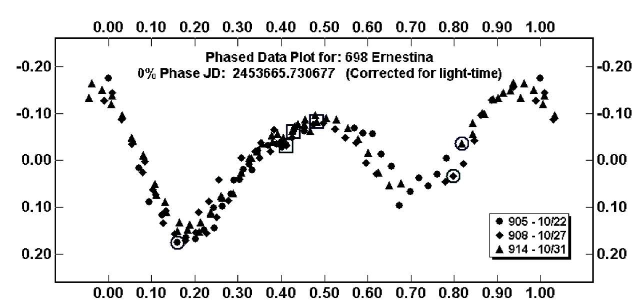
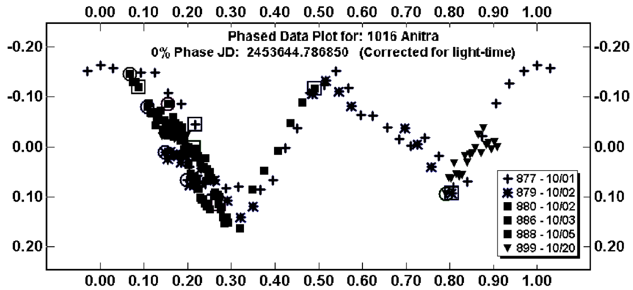
	Observers
1	Adrian Galad (Modra)
2	Marek Husarik (Skalnate Pleso)
3	David Higgins (Hunter's Hill), Walt Cooney, John Gross, Dirk Terrel (Sonoita Research)
4	Marek Husarik, Marian Jakubik, Gabrial Cervak, Michal Pikler (Skalnate Pleso)
5	Stefan Gajdos (Modra)
6	Peter Kusnirak (Ondrejov)
7	Donald Pray (Carbuncle Hill)
8	Jozef Világi (Modra)

Table II. List of Observers



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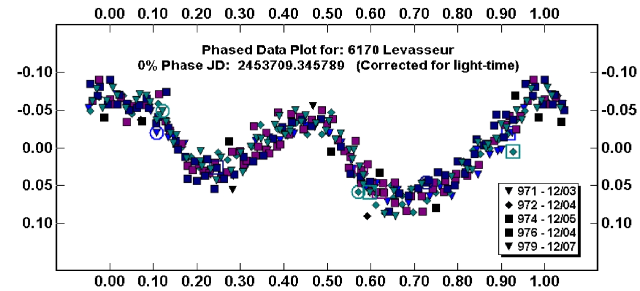
888 - 10/05
899 - 10/20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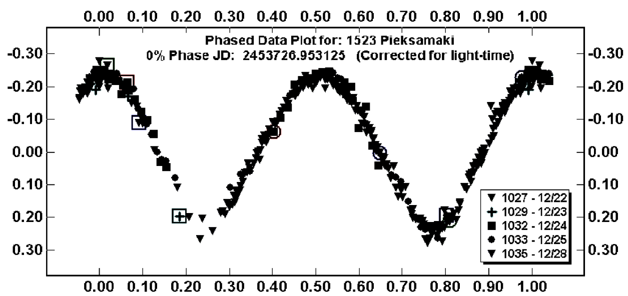
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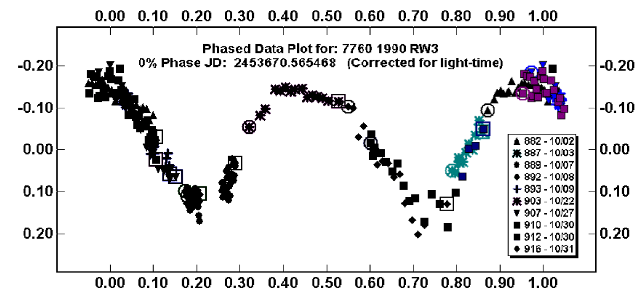
1035 - 12/28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882 - 10/02
887 - 10/03
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893 - 10/09
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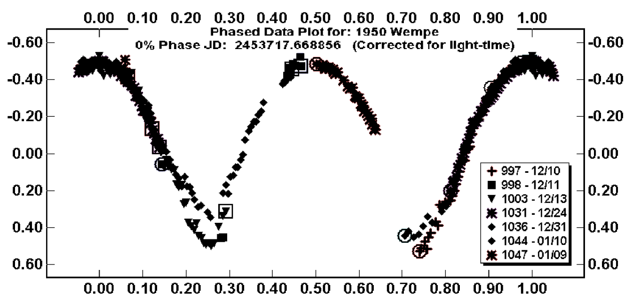
907 - 10/27
910 - 10/30
912 - 10/30
916 - 10/31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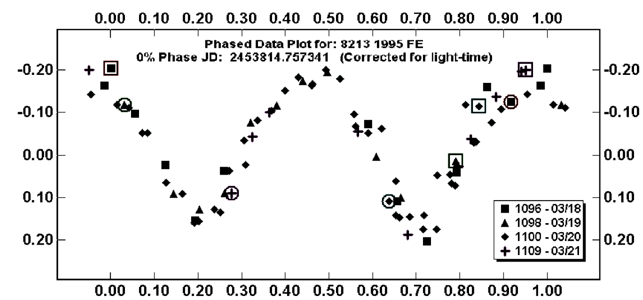
1044 - 01/10
1047 - 01/09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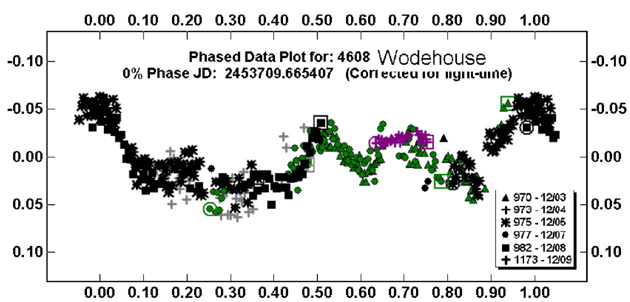
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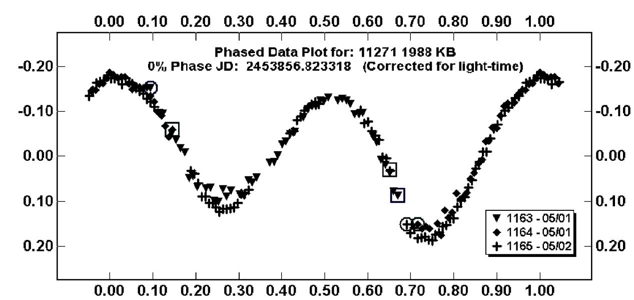
1173 - 12/09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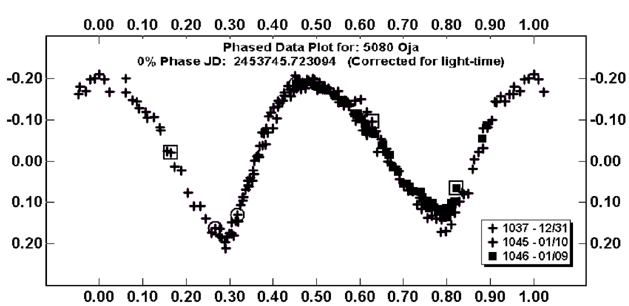
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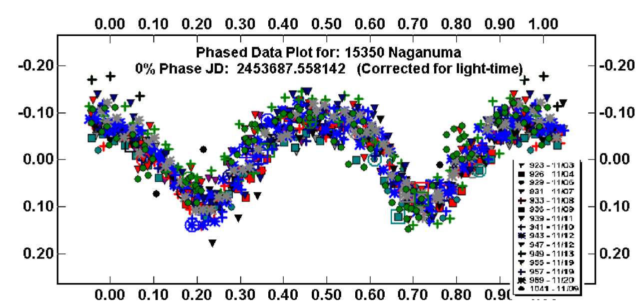
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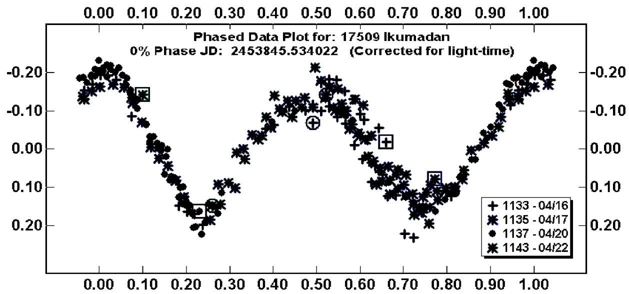

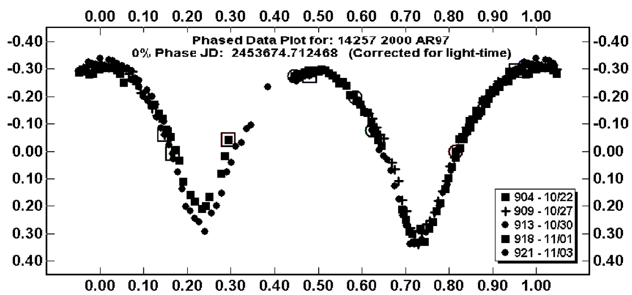

THE LIGHTCURVE OF MAIN-BELT ASTEROID 774 ARMOR

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Observations spanning more than two months reveal the synodic period of the main-belt asteroid 774 Armor to be 25.162±0.002hr with an amplitude of 0.37±0.02mag. This study affirmed the importance of both collaboration and having data from widely separated locations.

In early February and approximately one month later, authors Bennett and Fauerbach observed 774 Armor using a 0.4m Ritchey-Chretien telescope and Apogee AP7p at Florida Gulf Coast University. Assuming a period of about 22hr, their combined data covered a good portion of the entire lightcurve. However, due to the large lapses in time between runs, the possibility of aliases could not be entirely removed.

Starting in mid-April, Warner, not knowing of the earlier observations, started observing the asteroid using a 0.35m SCT and SBIG ST-9E. It became immediately clear that the period was long, possibly nearly commensurate with 24hr, which would have made resolving the lightcurve period very difficult from a single station. Higgins, who's Hunter's Hill Observatory is located about 140° west of the Palmer Divide Observatory, was contacted and agreed to contribute observations. Despite short observing runs the first two nights, Higgins – using a 0.36m SCT and SBIG ST-8E, managed to capture an extreme point each time, which made period analysis more certain.

Table I shows the phase angle and Phase Angle Bisector values for the first and last dates of observations in the combined data set. The phase angle reached a minimum of 2.3° on February 24 and was about 3.0° on the dates of observation at the first of March.

Date	Phase	L_{PAB}	B_{PAB}
2006 Feb 01	8.2	155.6	-6.5
2006 Apr 18	15.7	155.9	-6.2

Table I. The phase and Phase Angle Bisector values for the extreme dates of observations for 774 Armor.

Fauerbach saw Warner's report on the CALL site (http://www.MinorPlanetObserver.com/astlc/default.htm) and suggested a collaboration. A plot using the merged data set from all three locations and phased to the adopted period is shown in Figure 1. The combination of extended coverage, about 10 weeks, and a series of sessions spaced only one day apart allowed elimination of many suspected aliases, pointing to a synodic period of 25.162±0.002hr. The amplitude of the lightcurve is 0.37±0.02mag.

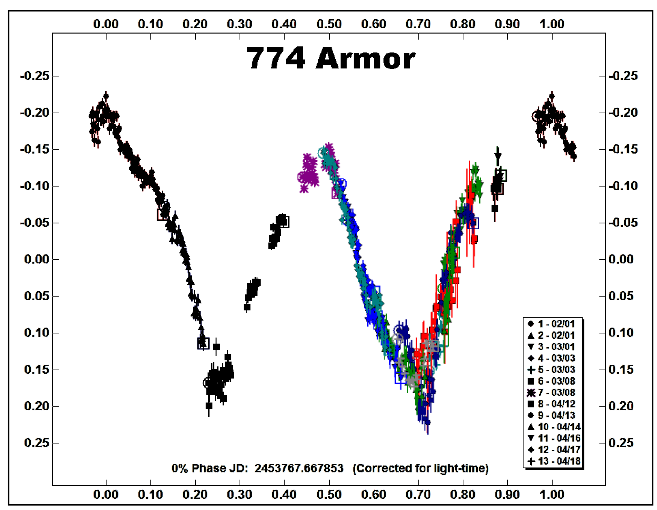

Figure 1. The lightcurve of 774 Armor phased to 25.162hr.

While the individual sets of data from Bennett/Fauerbach and Warner/Higgins arrived at similar results to the adopted period, each alone did not provide a complete and certain solution. In this case, sharing of data that covered an overall large span in time as well as extending a single run on consecutive dates provided a much higher degree of confidence in the results. This collaboration showed once again the importance in asteroid lightcurve work of making results and, more important, data openly available.

Acknowledgements

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