

ASTEROIDS OBSERVED FROM CS3: 2015 JULY - SEPTEMBER

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Lightcurves for 20 asteroids were obtained from the Center for Solar System Studies from 2015 July to September.

This calendar quarter the Center for Solar System Studies (CS3, MPC U81) selected targets of opportunity because of the short Northern Hemisphere summer nights, low ecliptic, and location of the Milky Way. This required selecting targets high in inclination such as Hungarias and Hildas. Some of these had previously determined rotational periods and further observations were acquired so that over time pole positions and shape models can be calculated.

All images were made with a 0.4-m or a 0.35-m SCT using an FLI-1001E or a SBIG STL-1001E CCD camera. Images were unbinned with no filter and had master flats and darks applied to the science frames prior to measurement. Measurements were made using *MPO Canopus*, which employs differential aperture photometry to produce the raw data. Period analysis was done using *MPO Canopus*, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris *et al.*, 1989). Night-to-night calibration of the data (generally $< \pm 0.05$ mag) was done using field stars converted to approximate Cousins V magnitudes based on 2MASS J-K colors (Warner 2007). The Comp Star Selector feature in *MPO Canopus* was used to limit the comparison stars to near solar color.

1600 Vyssotsky. Vyssotsky has been well studied over the years and a pole solution has been found. Warner (Warner 2014) observed this Hungaria in 1999, 2004, 2005, 2007, 2009, 2010, and 2014; each time finding a rotational period of about 3.2 h.

Observations were obtained this year to improve the pole solution model.

2253 Espinette. A rotational period for Espinette has been determined several times in the past. Wisniewski (Wisniewski *et al* 1995) reported a rotational period of 7.3 h. Behrend (Behrend 2015) and Skiff reported periods of 7.440 h and 7.442 h respectively. This result agrees with those prior period determinations.

2974 Holden. No previously reported results could be found in the Lightcurve Database (LCDB; Warner *et al.*, 2009) for this Vestoid. Given its long rotational period of 856 h, it would expected to see it in a tumbling state since the dampening time exceeds the age of the solar system. There are some hints of tumbling in individual nightly sessions, which cannot be seen in the compressed X-axis scale. However, since it took over a month to complete one rotation, it is not likely enough data could be acquired to determine a secondary frequency.

3561 Devine. For this Hilda, rotational periods of 4.376 h and 5.354 h have nearly identical strength solutions. I have adopted the 4.376 h period here, because the extrema are 50% phase apart. However, with an amplitude of 0.08 mag., the lightcurve could be asymmetric and dominated by surface features. A period spectrum is presented to show the various aliases.

6085 Fraethi. The Lightcurve Database (LCDB; Warner *et al.*, 2009) contains a rotational period for this Vestoid of 6.0 h reported by Behrend (Behrend 2015). However, a lightcurve plot cannot be found on that website.

6183 Viscome. Given its long rotational period, it is not usual that reported results could not be found in the Lightcurve Database (LCDB; Warner *et al.*, 2009). The Photometric Survey for Asynchronous Binary Asteroids (Parvec *et al* 2015) reported a period on their website of 437 h using much sparser data. I was able to obtain coverage of about 110% of the phased lightcurve, which shows signs of tumbling as the magnitude at the first maximum are much greater at the start of the run than at the end of the run.

Number	Name	2015		Pts	Phase	L _{PAB}	B _{PAB}	Period	P.E.	Amp	A.E.	Grp
		mm/dd	mm/dd									
1600	Vyssotsky	09/29-09/30	09/29-09/30	106	26.2,25.8	44	-15	3.204	0.003	0.21	0.02	H
2253	Espinette	08/02-08/10	08/02-08/10	165	32.2,29.7	356	-2	7.442	0.001	0.44	0.01	MC
2468	Repin	07/03-07/12	07/03-07/12	142	30.6,29.8	348	6	5.122	0.001	0.72	0.02	V
2974	Holden	08/29-10/03	08/29-10/03	176	21.5,4.1	13	4	856	2	0.7	0.05	V
3202	Graff	07/21-07/25	07/21-07/25	234	4.3,3.8	309	12	17.32	0.02	0.18	0.02	HIL
3561	Devine	07/07-07/15	07/07-07/15	127	12.8,14.1	241	8	4.376	0.002	0.08	0.01	HIL
4302	Markeev	07/09-07/13	07/09-07/13	171	20.6,19.4	329	2	5.134	0.002	0.31	0.02	V
6085	Fraethi	08/31-09/03	08/31-09/03	186	5.0,5.7	336	7	5.556	0.001	0.79	0.02	V
6183	Viscome	09/03-09/27	09/03-09/27	123	21.4,25.2	346	30	453	10	0.9	0.1	PHO
6189	Volk	08/28-09/06	08/28-09/06	438	20.9,17.4	11	7	2.896	0.001	0.18	0.02	V
6984	Lewiscarrol	07/14-07/29	07/14-07/29	587	11.0,8.8	338	15	24.65	0.05	0.16	0.02	HIL
7187	Isobe	09/29-09/30	09/29-09/30	137	31.1,31.0	49	29	4.241	0.006	0.22	0.03	H
17399	Andysanto	08/21-08/24	08/21-08/24	271	26.9,25.7	4	6	2.692	0.001	0.07	0.02	H
20037	Duke	08/03-08/06	08/03-08/06	184	28.1,28.5	301	36	5.29	0.01	0.17	0.03	H
23715	1998 FK2	08/23-08/28	08/23-08/28	187	24.9,22.6	5	6	7.434	0.002	0.36	0.03	H
27351	2000 DO73	08/11-08/17	08/11-08/17	226	28.2,25.9	356	-2	9.008	0.003	0.16	0.02	MC
37744	1996 XU14	08/08-08/22	08/08-08/22	676	24.3,18.7	351	9	35.51	0.007	0.73	0.02	H
47143	1999 LL31	07/16-07/17	07/16-07/17	77	15.0,15.1	284	22	3.312	0.004	0.36	0.03	H
53453	1999 XX135	08/18-08/20	08/18-08/20	183	20.0,19.6	344	24	3.407	0.002	0.37	0.02	H
74590	1999 OG2	07/26-08/06	07/26-08/06	600	26.6,22.8	329	26	33.409	0.005	0.86	0.02	H

6984 Lewiscarrol. No previously reported results could be found in the Lightcurve Database (LCDB; Warner et al., 2009). This is not surprising as the rotational period has gone down the rabbit hole. I have adopted a rotational period of 24.65 h, nearly commensurate with the Earth's rotation. However, as the Period Spectrum shows, there are strong aliases near 12 h and 48 h, which are possible scenarios for this low amplitude lightcurve.

7187 Isobe. This Hungaria has also been studied extensively by Warner (Warner 2013b) with observations in 2004, 2007, 2011, and 2012. Observations in 2004 and 2012 suggest that Isobe is probably a binary, with a secondary period near 33 h. The two nights of observations in 2015 did not reveal any mutual events.

20037 Duke. Warner (Warner 2011), reported that this Hungaria was a weak candidate to be a binary, with a primary period of 5.428 h. At this opposition, the lightcurve was dominated by noise and a secondary period could not be extracted. The derived rotational period of 5.29 h is in fair agreement with the Warner result.

(23715) 1998 FK2. This Hungaria was previously observed by Warner (Warner 2013) who found a rotational period of 7.436 h. This year's result is in agreement with that period.

(47143) 1999 LL31. Warner (Warner 2012) reports a rotational period of 3.32 h. Using data from the Palomar Transient Factory (PTF) Survey, Waszczak (Waszczak et al 2015) reports a period of 3.3262. This result agrees with those previously reported periods.

(74590) 1999 OG2. Using the PTF data, Waszczak (Waszczak et al 2015) reports a period of 33.3185 h. Warner (Warner 2008) previously found a similar period of 33.273 h. My result is agrees with those periods.

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