LIGHTCURVE ANALYSIS OF HILDA ASTEROIDS AT THE CENTER FOR SOLAR SYSTEM STUDIES: 2021 SEPTEMBER-DECEMBER

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CCD photometric observations of five Hilda asteroids made between 2021 September-December. Data analysis found that four were in simple principal axis rotation, i.e., a single rotation period could be found. On the other hand, revised analysis of data obtained in 2018 for 1748 Mauderli showed potential signs of a satellite.

CCD photometric observations of five Hilda asteroid were carried out at the Center for Solar System Studies (CS3) from 2021 September through December as part of an ongoing study of the family/group that is located between the outer main-belt and Jupiter Trojans in a 3:2 orbital resonance with Jupiter. The goal is to determine the spin rate statistics of the Hildas and to find pole and shape models when possible. We also look to examine the degree of influence that the YORP (Yarkovsky-O'Keefe-Radzievskii-Paddack) effect (Rubincam, 2000) has on distant objects and to compare the spin rate distribution against the Jupiter Trojans, which can provide evidence that the Hildas are more "comet-like" than main-belt asteroids.

Telescopes	Cameras
0.30-m *f*/6.3 Schmidt-Cass	FLI Microline 1001E
0.35-m *f*/9.1 Schmidt-Cass	FLI Proline 1001E
0.35-m *f*/11 Schmidt-Cass	SBIG STL-1001E
0.40-m f/10 Schmidt-Cass	
0.50-m *f*/8.1 Ritchey-Chrétien	

Table I. List of available telescopes and CCD cameras at CS3. The exact combination for each telescope/camera pair can vary due to maintenance or specific needs.

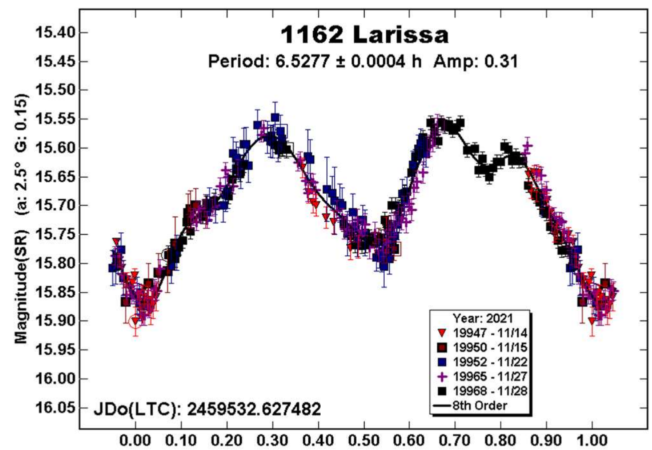
Table I lists the telescopes and CCD cameras that are combined to make observations. Up to nine telescopes are commonly used for observations. All the cameras use CCD chips from the KAF blue-enhanced family and so have essentially the same response. The pixel scales ranged from 1.24-1.60 arcsec/pixel. All lightcurve observations were unfiltered since a clear filter can result in a 0.1-0.3 magnitude loss. The exposures varied depending on the asteroid's brightness.

To reduce the number of times and amounts of adjusting nightly zero-points, the ATLAS catalog r´ (SR) magnitudes (Tonry et al., 2018) are used. Those adjustments are usually ≤ ±0.03 mag. The rare greater corrections may have been related in part to using unfiltered observations, poor centroiding of the reference stars, and not correcting for second-order extinction. Another cause may be selecting what appears to be a single star but is actually an unresolved pair.

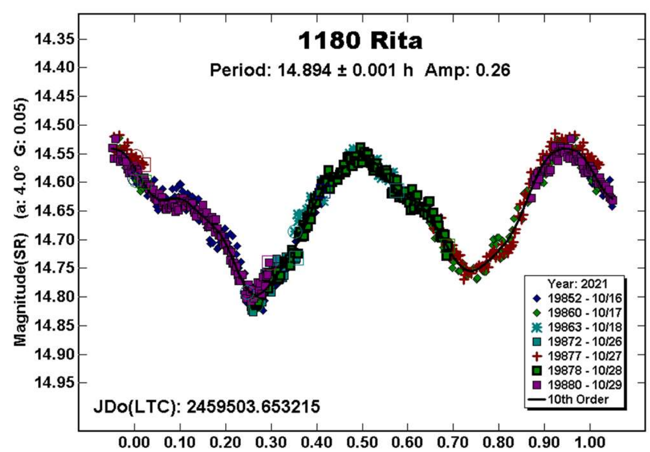
The Y-axis values are ATLAS SR "sky" (catalog) magnitudes. The two values in the parentheses are the phase angle (a) and the value of *G* used to normalize the data to the comparison stars used in the earliest session. This, in effect, made all the observations seem to be made at a single fixed date/time and phase angle, leaving any variations due only to the asteroid's rotation and/or albedo changes. The X-axis shows rotational phase from -0.05 to 1.05. If the plot includes the amplitude, e.g., "Amp: 0.65", this is the amplitude of the Fourier model curve and *not necessarily the adopted amplitude for the lightcurve*.

For brevity, only some of the previous results are referenced. A more complete listing is in the asteroid lightcurve database (Warner et al., 2009; "LCDB" from here on).

1162 Larissa. There are several previously reported periods in the LCDB for Larissa, including Warner and Stephens (2021; 6.53 h). All previous results had very similar periods, save Dahlgren et al. (1998), who found a period of 13.0 h.

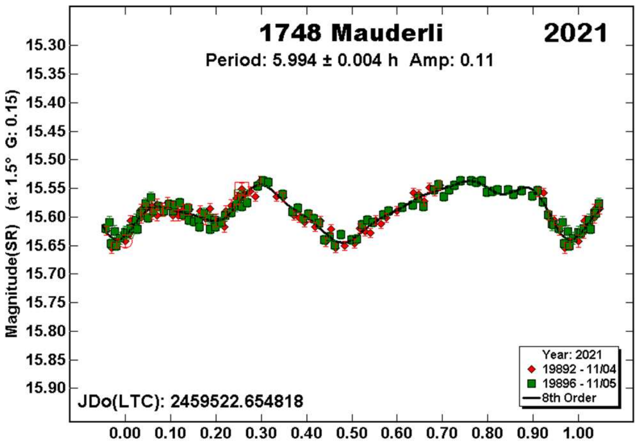


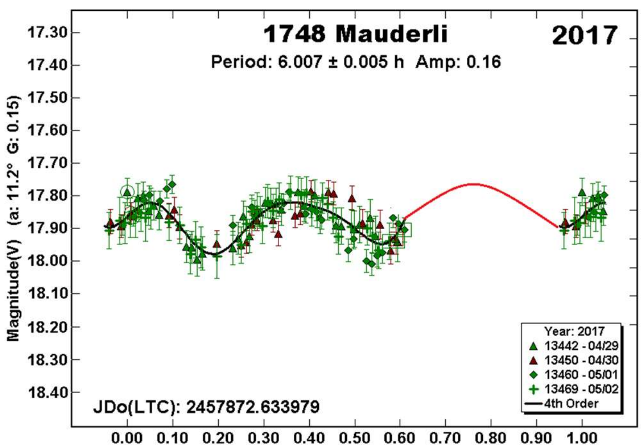
1180 Rita. Dahlgren et al. (1998) found a period of 14.902 h. In a previous paper (Warner and Stephens, 2017a), a period of 13.090 h was found, but subsequent review of those results revised the period to 14.928 h using data from 2017 and 14.849 h using data from 2018 (Warner and Stephens, 2018). The most recent CS3 result is consistent with Dahlgren et al. (1998) and the revised periods.

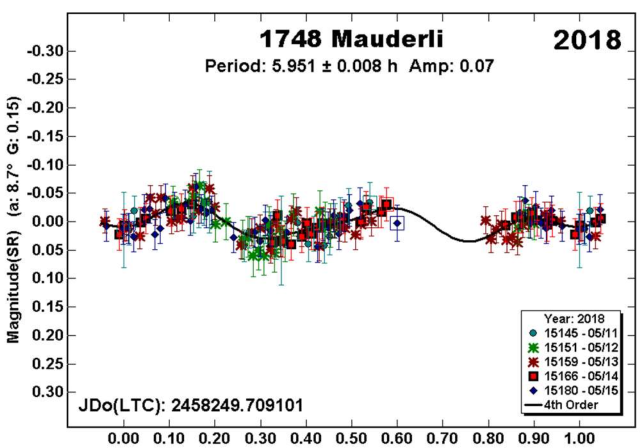


1748 Mauderli. Dahlgren et al. (1998) found a period of 6.00 h. Data obtained at CS3 in 2017 found a shorter period of 5.552 h (Warner and Stephens, 2017b). When observed again in 2018 (Warner and Stephens, 2018), a period of 5.320 h was found and the 2017 result was reconfirmed to within 0.001 h. Both appear to be wrong.

Romanishin has observed Mauderli several times, the most recent being in 2020 (Romanishin, 2021). Using data from four apparitions, he was able to establish that the true period was close to 6.00 h and a period near 5.55 h was implausible. He also reported signs of a second period in his 2018 data but its origin was not established. Based on the Romanishin (2021) results, the period search using the 2021 CS3 data was confined to near 6 h. The result of 5.994 h is in good agreement with Romanishin (2021).



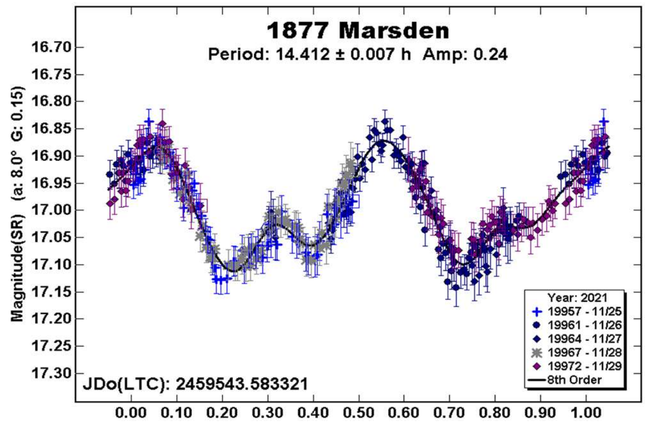




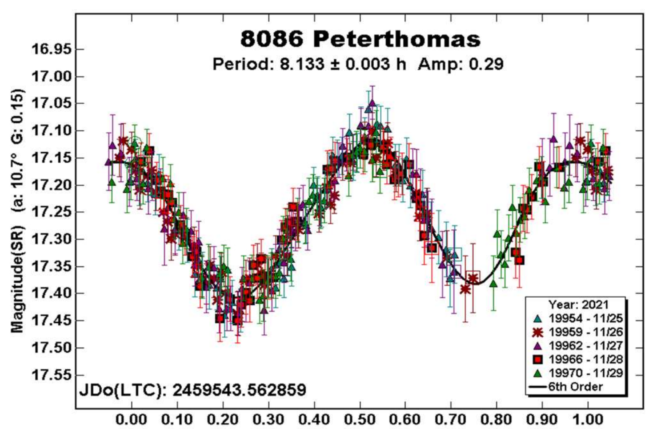
The data from 2017 and 2018 were analyzed anew, but forcing a period solution near 6 h. The gap in the 2017 data sent the Fourier curve soaring to unrealistic heights. The red line in that plot is an attempt to complete the curve.

A suspicious secondary period was found in the 2018 data set. The period was 37.9 h but the coverage is too sparse to consider it a valid solution. The best that can be said is that after two possible sightings (2014 and 2018), future observers should be aware of the possibility of a satellite, or at least a second period, and obtain high-quality data.

1877 Marsden. Dahlgren et al. (1998) found a period of 14.4 h. In 2018 (Warner and Stephens, 2018), a period of 13.18 h was found, which *seemed* at the time to be more likely correct. Pal et al. (2020) used dense TESS lightcurve data to find 14.4319 h. The analysis of the most recent CS3 data set yields a similar period of 14.412 h. Attempts to force the 2018 data to a period near 14.4 h and the 2021 data to a period near 13.18 h were fruitless.



8086 Peterthomas. The results from the latest data set yield a period that is highly consistent with previous results in the LCDB.



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Number	Name	2021/mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
1162	Larissa	11/14-11/28	2.6,6.0	60	1	6.5277	0.0004	0.31	0.02
1180	Rita	10/16-10/29	4.0,7.1	12	-8	14.894	0.001	0.25	0.02
1748	Mauderli	2021/11/04-11/05	1.5,1.3	44	-4	5.994	0.004	0.11	0.01
		2017/04/29-05/02	11.2,11.4	159	2	[R]6.007	0.005	0.16	0.02
		2018/05/11-05/15	8.7,9.5	194	4	[R]5.951	0.008	0.07	0.01
1877	Marsden	11/25-11/29	8.0,8.7	37	15	14.412	0.007	0.24	0.02
8086	Peterthomas	11/25-11/29	10.8,11.6	26	1	8.133	0.003	0.29	0.02

Table II. Observing circumstances. [R]Revised period. The phase angle (α) is given at the start and end of each date range. L_{PAB} and B_{PAB} are the average phase angle bisector longitude and latitude (see Harris *et al.*, 1984).

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