LIGHTCURVE ANALYSIS OF HILDA ASTEROIDS AT THE CENTER FOR SOLAR SYSTEM STUDIES: 2020 OCTOBER-DECEMBER

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New CCD photometric observations of two Hilda asteroid members were made from 2020 October through December: 748 Simeisa and 1754 Cunningham. The latest data for Simeisa conclusively reject earlier reports of a period near 11.9 h.

CCD photometric observations of Hilda asteroids are made at the Center for Solar System Studies (CS3) as part of an ongoing study of this 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	

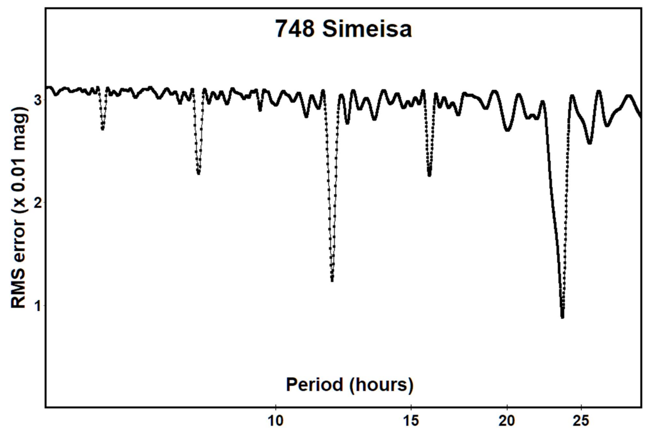
Table I. List of available telescopes and CCD cameras at CS3. The exact combination for each telescope/camera pair can vary due to maintenance or specific needs.

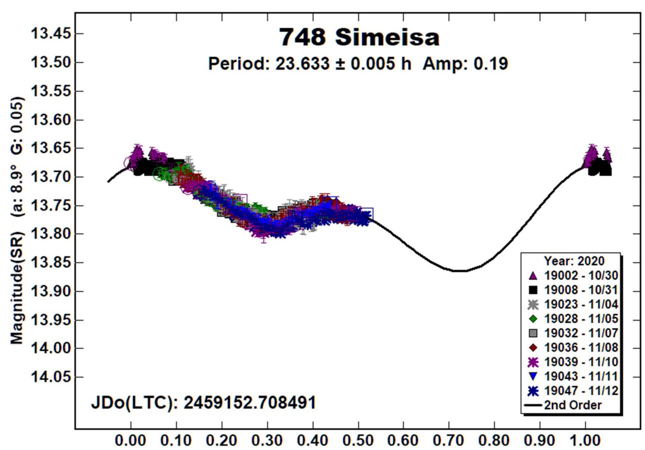
Table I lists the telescopes and CCD cameras that are combined to make observations. Up to seven telescopes are commonly used for observations. All the cameras use CCD chips from the KAF blue-enhanced family and so have essentially the same response. The pixel scales ranged from 1.24-1.60 arcsec/pixel. 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.

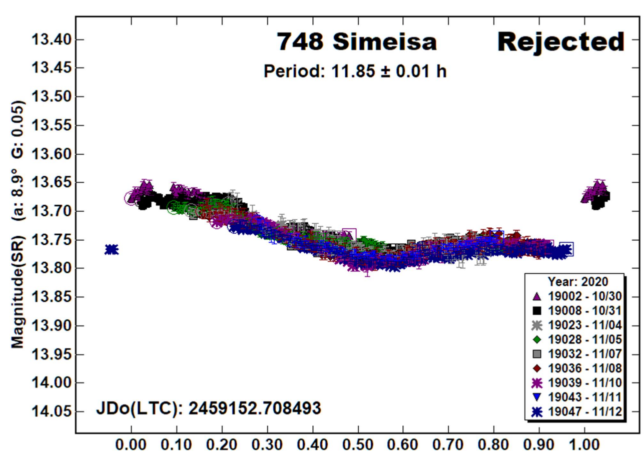
To reduce the number of times and amounts of adjusting nightly zero points, we use the ATLAS catalog r´ (SR) magnitudes (Tonry et al., 2018). Those adjustments are usually ≤ ±0.03 mag. The rare greater corrections may have been related in part to using unfiltered observations, poor centroiding of the 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*.

748 Simeisa. The estimated effective diameter of Semeisa is about 105 km. Dahlgren et al. (1998) reported a period of 11.88 h and Behrend (2011web) found 11.919 h. This made the period very close to one-half an Earth day, which can lead to rotational aliasing if the lightcurve shape is highly symmetrical.





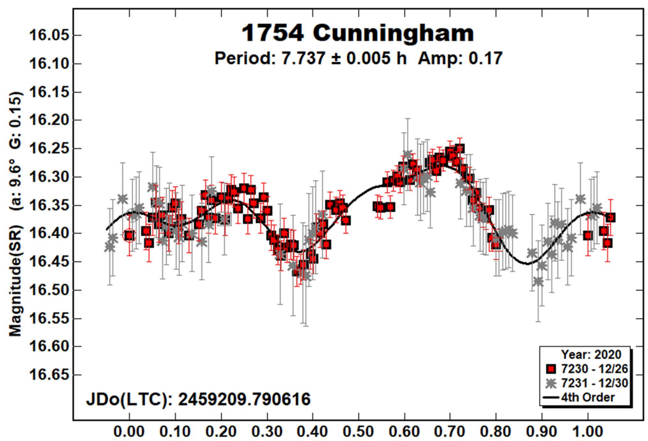


Number	Name	20yy/mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.
748	Simeisa	10/30-11/12	8.9,4.7	63	1	23.633	0.005	0.19	0.01
1754	Cunningham	12/26-12/30	9.6,9.0	138	-7	7.737	0.005	0.17	0.03

Table II. Observing circumstances. 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).

Ideally, a collaboration among several observers at different longitudes is best suited to reject at least some potential ambiguous solutions. Despite this, analysis of our observations from only CS3 provided a convincing case that the true period is 23.633 h, or very close to double the earlier results. This is supported by forcing the data to a period near 11.9 h as shown in the "Rejected" lightcurve. This shows a sharp discontinuity that has no reasonable physical interpretation.

1754 Cunningham. There were several previous entries in the asteroid lightcurve database (LCDB; Warner et al., 2009). Dahlgren et al. (1998) found a period of 4.285 while Slyusarev et al. (2012) reported 5.16 h. All other results, however, are close to 7.7 h: Behrend (2008web; 7.7398 h), Stephens (2015; 7.7416 h), and Warner and Stephens (2018; 7.709 h). The analysis of our most recent data supports the previous results near 7.7 h.



Acknowledgements

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References

Behrend, R. (-2008web; -2011web). Observatoire de Geneve web site., *http://obswww.unige.ch/~behrend/page_cou.html*

Dahlgren, M.; Lahulla, J.F.; Lagerkvist, C.-I.; Lagerros, J.; Mottola, S.; Erikson, A.; Gonano-Beurer, M.; Di Martino, M. (1998). "A Study of Hilda Asteroids. V. Lightcurves of 47 Hilda Asteroids." *Icarus* **133**, 247-285.

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

Rubincam, D.P. (2000). "Relative Spin-up and Spin-down of Small Asteroids." *Icarus* **148**, 2-11.

Stephens, R.D. (2015). "Asteroids Observed from CS3: Results for 1754 Cunningham and 7023 Heiankyo." *Minor Planet Bull*. **42**, 279.

Slyusarev, I.G.; Shevchenko, V.G.; Belskaya, I.N.; Krugly, Yu.N.; Chiorny, V.G. (2012). "CCD Photometry of Hilda Asteroids." ACM 2012, #6398.

Tonry, J.L.; Denneau, L.; Flewelling, H.; Heinze, A.N.; Onken, C.A.; Smartt, S.J.; Stalder, B.; Weiland, H.J.; Wolf, C. (2018). "The ATLAS All-Sky Stellar Reference Catalog." *Astrophys. J.* **867**, A105.

Warner, B.D.; Harris, A.W.; Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146. Updated 2020 Sep. *http://www.minorplanet.info/lightcurvedatabase.html*

Warner, B.D.; Stephens, R.D. (2018). "Lightcurve Analysis of Hilda Asteroids at the Center for Solar System Studies: 2017 July Through September" *Minor Planet Bull*. **45**, 35-39.