

NEW LIGHTCURVES OF 153 HILDA, 293 BRASILIA, AND 318 MAGDALENA

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Synodic rotation periods and amplitudes are found for
153 Hilda: 5.9585 ± 0.0001 h, 0.22 ± 0.01 mag; 293
Brasilia: 8.173 ± 0.001 h, 0.17 ± 0.01 mag; and
318 Magdalena: 42.65 ± 0.01 h, 0.08 ± 0.01 mag.

Observations to obtain the data used in this paper were made at the Organ Mesa Observatory with a 0.35-meter Meade LX200 GPS Schmidt-Cassegrain (SCT) and SBIG STL-1001E CCD. Exposures were 60 sec, unguided, with a clear filter. Photometric measurement and lightcurve construction was with *MPO Canopus* software. To reduce the number of points on the lightcurves and make them easier to read, data points have been binned in sets of 3 with a maximum time difference of 5 min.

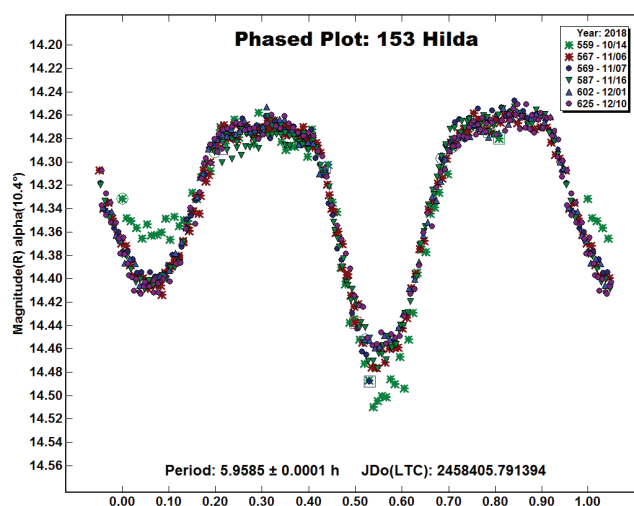
153 Hilda. The asteroid lightcurve data base (Warner et al., 2009) includes several period determinations near 5.957 h with amplitudes that vary with the phase angle bisector longitude (L_{PAB}). They are listed below in sequence of increasing L_{PAB} .

Author	Obs Date yyyy mm/dd	L_{PAB}	Amp
Warner and Stephens 2018	2017 09/10	29	0.11
Shevchenko et al. 2009	2002 11/21	65	0.20
Shevchenko et al. 2009	2005 05/22	148	0.20
Shevchenko et al. 2009	2006 04/16	195	0.07
Shevchenko et al. 2009	1992 07/29	323	0.05
Warner et al. 2017	2016 07/16	336	0.04

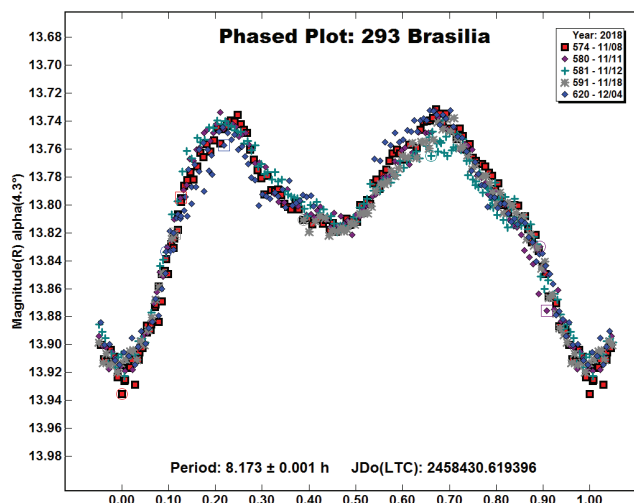
Table I. Listing of previous results giving the authors, approximate mid-date of observations, the PAB longitude, and lightcurve amplitude.

Two other published rotation periods are 8.11 h (Zappala et al., 1989) and 5.11 h (Lagerkvist et al. 1995). New observations on six nights from 2018 Oct. 14 through Dec. 10 provide a good fit to an unsymmetrical bimodal lightcurve with period 5.9585 ± 0.0001 h and amplitude 0.22 ± 0.01 mag at phase angle bisector longitude 70 deg. The period is consistent with many other period determinations and the amplitude is the largest yet observed.

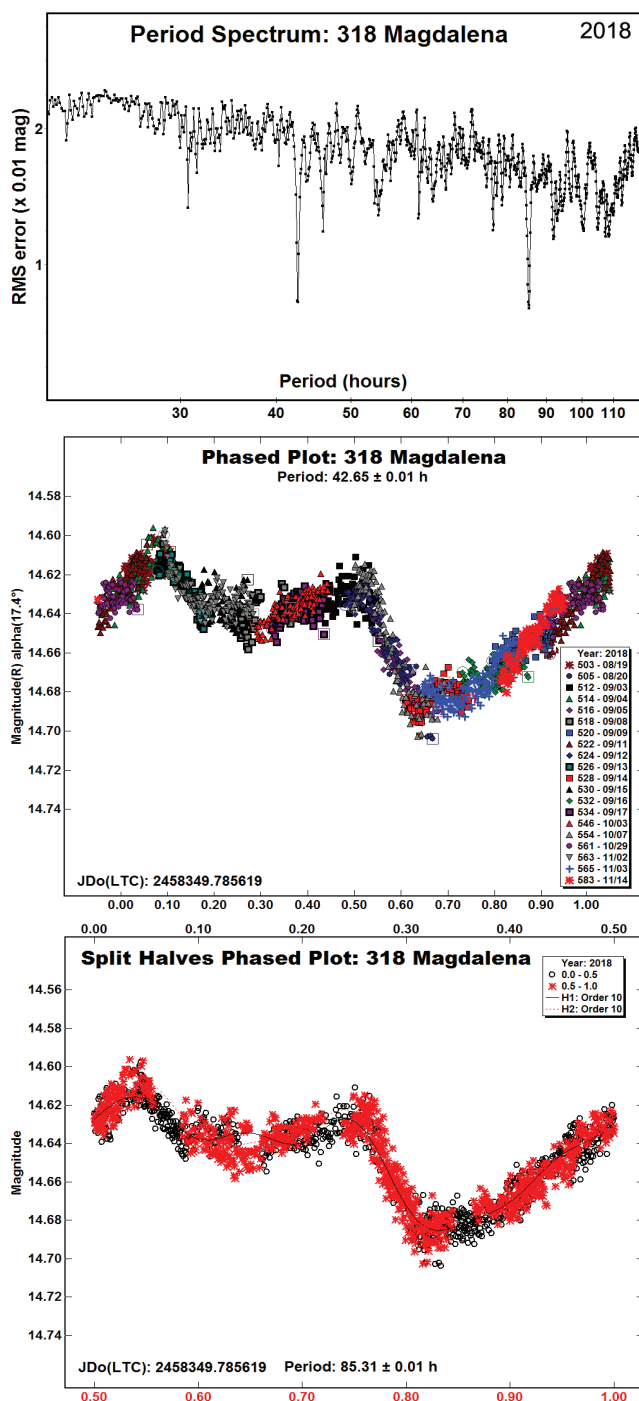
The amplitude-aspect relationship is an approximate method used for several decades to find the location of the rotational pole. It presumes that the amplitude is proportional to the sine of the angle between the line of sight and the rotational pole. From the table above, the pole is probably near celestial longitude 330 deg, latitude ± 15 deg. The current observations were likely near the asteroid equator and the phase angle bisector moved primarily in latitude through the interval of observation. This means that the synodic period of 5.9585 h established in this study is close to the sidereal period; this is information that is useful for future lightcurve inversion modeling.



293 Brasilia. Previously published period determinations are 6.518 h (Behrend, 2005) and parallel studies near the year 2006 opposition: 8.173 h (Oey, 2006) and 8.17 h (Stephens, 2006). New observations on five nights from 2018 Nov. 8 through Dec. 4 provide a good fit to an unsymmetrical bimodal lightcurve with period 8.173 ± 0.001 h, amplitude 0.17 ± 0.01 mag. This is in good agreement with the periods found by Oey and by Stephens.



318 Magdalena. In the asteroid lightcurve data base (LCDB; Warner et al., 2009, updated 2018 November), 318 Magdalena is the lowest numbered asteroid whose rotation period reliability is listed as less than 3-. Previously published period determinations are 59.5 h (Behrend, 2004), and 42.49 h (Pilcher and Martinez, 2015) with a slightly asymmetric bimodal lightcurve that looks convincing. New observations on 20 nights provide a good fit to a highly asymmetric bimodal lightcurve with period 42.65 ± 0.01 h, amplitude 0.08 ± 0.01 mag. The observations include about 95% of the double period 85.31 h. A split-halves plot of the double period shows close agreement between the two halves of the double period. This is additional evidence that favors the 42.65-hour period over the double period. A period spectrum between 20 hours and 120 hours is also provided, for which the only deep minima are at 42.65 and 85.31 h, respectively. The 2015 and 2018 lightcurves have very different shapes, indicating that their viewing aspects were at very different asteroidcentric latitudes. The synodic period determinations for these years are compatible.



After 318 Magdalena there are 13 other asteroids numbered 500 and below whose rotation periods are listed in Warner et al. (2009) with reliability 2+ or less, i.e., not fully reliable. These are numbers 357, 384, 395, 421, 426, 445, 449, 455, 464, 470, 488, 491, 494. For most of these objects, the period is poorly established because it is very long, the amplitude is small, or both.

Number	Name	yyyy/mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E	Amp	A.E
153	Hilda	10/14-12/10	2076	10.4, 0.8, 2.3	70	-3	5.9585	0.0001	0.22	0.01
293	Brasilia	11/08-12/04	1933	4.2, 0.9, 6.9	55	-2	8.173	0.001	0.17	0.01
318	Magdalena	08/19-11/14	5174	17.4, 4.8, 9.4	70	-9	42.65	0.01	0.08	0.01

Table II. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first date, minimum value reached, and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (Harris et al., 1984).

It will require much persistence and telescope time to acquire sufficient data to obtain a secure period for each of them. Current rotation statistics are skewed away from long periods and low amplitudes due to difficulty of observation. Obtaining unbiased statistics requires that the difficult objects be solved.

References

- Behrend, R. (2004, 2005, 2010). Observatoire de Geneve web site. http://obswww.unige.ch/~behrend/page_cou.html.
- 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.
- Lagerkvist, C.-I., Di Martino, M., Blanco, C., Dahlgren, M., Erikson, A., Lahulla, J.F., Lazzarin, M., Lumme, K., Pohjolainen, S., Riccioli, D. (1995). "Physical studies of asteroids XXX: The asteroid 153 Hilda." *Earth, Moon, and Planets* **71**, 189-194.
- Oey, J. (2006). "Lightcurve analysis of 10 asteroids from Leura Observatory." *Minor Planet Bull.* **33**, 96-99.
- Pilcher, F., Martinez, L. (2015). "Rotation Period Determinations for 318 Magdalena and 335 Roberta." *Minor Planet Bull.* **42**, 239.
- Shevchenko, V.C., Tungalag, N., Chiorny, V.C., Gaftonyuk, N.M., Krugly, Yu.N., Harris, A.W., Young, J.W. (2009). "CCD-photometry and pole coordinates for eight asteroids." *Plan. Space Sci.* **57**, 1514-1520.
- Stephens, R.D. (2006). "Asteroid lightcurve photometry from Santana and GMARS observatories – winter and spring 2006." *Minor Planet Bull.* **33**, 100-101.
- Warner, B.D., Harris, A.W., Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146. Updated 2018 Nov. <http://www.minorplanet.info/lightcurvedatabase.html>.
- Warner, B.D., Stephens, R.D., Coley, D.R. (2017). "Lightcurve analysis of Hilda asteroids at the Center for Solar System Studies: 2016 June-September." *Minor Planet Bull.* **44**, 36-41.
- 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.
- Waszczak, A., Chang, C.-K., Ofek, E.O., Laher, R., Masci, F., Levitan, D., Surace, J., Cheng, Y.-C., Ip, W.H., Kinoshita, D., Helou, G., Prince, T.A., Kulkarni, S. (2015). "Asteroid Light Curves from the Palomar Transient Factory Survey: Rotation Periods and Phase Function from Sparse Photometry." *Astron. J.* **150**, A75.
- Zappala, V., Di Martino, M., Cellino, A., Farinello, P., De Sanctis, C. (1989). "Rotational properties of outer belt asteroids." *Icarus* **82**, 354-368.