ROTATIONAL PERIOD AND POST OPPOSITION H_R-G PARAMETERS DETERMINATION FOR 3250 MARTEBO

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Photometric measurements for asteroid 3250 Martebo were performed during its 2013 favorable opposition. The synodic rotation period was found to be 9.495 ± 0.001 h, the lightcurve amplitude was 0.52 ± 0.04 mag, the absolute magnitude was H_R = 10.841 ± 0.025 mag, and the slope parameter was G = 0.101 ± 0.033. These lead to an estimated diameter of D = 31 ± 4 km.

3250 Martebo is a small main-belt asteroid discovered in 1979 by C. Lagerkvist at Mount Stromlo (US). It appeared on the CALL web site (*http://www.MinorPlanet.info/call.html*) as an asteroid photometry opportunity due to it reaching a favorable apparition in 2013 and having no defined lightcurve parameters.

Unfiltered CCD photometric images were taken at Observatorio Los Algarrobos, Salto, Uruguay (MPC Code I38) in 2013 from October 22 (shortly after opposition) to December 24. The telescope was a 0.3-m Meade LX-200R reduced to *f*/6.9. The CCD imager was a QSI 516wsg NABG (non-antiblooming gate) with a 1536x1024 array of 9-micron pixels and 23x16 arcminute field-of-view. The exposures increased from 90 to 240 seconds as the asteroid faded past-opposition (see Table I). 2x2 binning was used, yielding an image scale of 1.77 arcseconds per pixel. The camera was set to –10° C and off-axis guided by means of an SX Lodestar camera and *PHD Guiding* (Stark Labs) software. Image acquisition was done with *MaxIm DL5* (Diffraction Limited). The computer was synchronized with atomic clock time via Internet NTP servers at the beginning of each session.

All images were dark and flat-field corrected and then measured using *MPO Canopus* (Bdw Publishing) version 10.4.3.16 with a differential photometry technique. The data were light-time corrected. Night-to-night zero point calibration was accomplished by selecting up to five comp stars with near solar colors according to recommendations by Warner (2007) and Stephens (2008). Period analysis was also done with *MPO Canopus*, which incorporates the Fourier analysis algorithm developed by Harris (Harris *et al.*, 1989).

More than 58 hours of effective observation and about 1,370 data points were required in order to solve the lightcurve (Figure 1). Over the span of observations, the phase angle varied from 1.8º to 20.2º, the phase angle bisector ecliptic longitude from 24.6º to 29.8º, and the phase angle bisector ecliptic latitude from –0.2º to –2.9º. The rotation period for 3250 Martebo was determined to be 9.495 ± 0.001 h along with a peak-to-peak amplitude of 0.52 ± 0.04 mag. The lightcurve showed a typical bimodal shape, with the maxima virtually identical in magnitude and the minima differing by only a small – although noticeable – amount. No clear evidence of tumbling or binary companion was seen in the lightcurve.

The absolute *R*-band magnitude (H_R) and slope parameter (G) were found using the H-G Calculator tool of *MPO Canopus*, which is based on the FAZ algorithm developed by Alan Harris (1989). Thirteen post-opposition data were used (Table I), all of them

Sess	Date	Span	Exp	Phase	R mag
188	10/22	5.1	90	1.79	14.40-14.86
189	10/23	5.0	90	2.22	14.47-14.98
190	10/25	3.6	105	3.09	14.49-14.85
191	10/28	5.1	120	4.39	14.60-15.11
193	11/05	6.0	150	7.71	14.82-15.44
194	11/06	5.4	150	8.16	14.89-15.59
195	11/22	4.8	180	13.76	15.22-15.82
196	11/23	5.0	180	14.06	15.29-15.75
198	12/01	4.4	240	16.24	15.46-16.05
199	12/04	4.2	240	16.94	15.45-15.97
200	12/21	3.1	240	19.82	15.67-16.33
201	12/22	3.4	240	19.94	15.83-16.60
202	12/24	3.0	240	20.15	15.91-16.62

Table I. Observing circumstances. All dates are in 2013. The imaging intervals (Span) are expressed in hours and the exposure times (Exp) are in seconds.

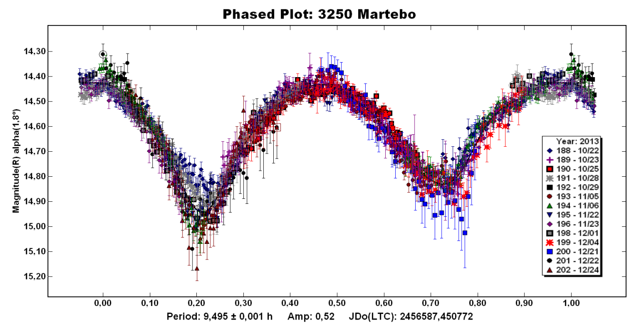

Figure 1. Composite lightcurve of 3250 Martebo.

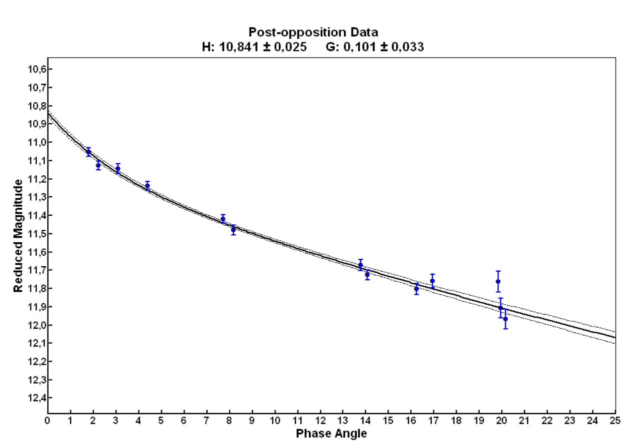

Figure 2. H-G plot in *R*-band magnitude for 3250 Martebo.

representing the maximum of the curve for each observing session. The absolute *R*-band magnitude was determined to be 10.841 ± 0.025 mag and the slope parameter 0.101 ± 0.033 (Figure 2). Such a low G parameter is typical of low albedo asteroids (Lagerkvist and Magnusson, 1990).

Assuming a taxonomic class C, the geometric albedo on the Johnson V band becomes p_V = 0.06 ± 0.02 and the color index V-R = 0.38 ± 0.05 (Shevchenko and Lupishko, 1998), which makes the absolute magnitude H_V = 11.22 ± 0.06. By using the formula by Pravec and Harris (2007) for the asteroid diameter (D) in kilometers:

$$D = \frac{1329}{\sqrt{p_V}} 10^{-0.2H}$$

this gives an estimated diameter of D = 31 ± 4 km.

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ROTATION PERIOD DETERMINATION FOR 67 ASIA

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New photometric observations of 67 Asia indicate a synodic rotation period of 15.853 ± 0.001 hours with amplitude 0.22 ± 0.02 magnitudes.

Previous rotation period determinations are by Harris and Young (1980), 15.89 hours; Armstrong, Nellermoe, and Reitzler (1996), 15.89 hours; and Ditteon and Hawkins (2007), 15.90 hours. Of these by far the most comprehensive is Harris and Young (1980). They obtained approximately 6 hours of data each night for 8 consecutive nights 1978 July 25 - Aug. 1. Lightcurves on consecutive nights looked very different while those on alternate nights looked the same. These results they interpreted as representing a period near 16 hours with the usual bimodal lightcurve, with observations on consecutive nights occurring at intervals of 1.5 rotational cycles, and appproximately 3/4 phase coverage. Periods near 8 hours with monomodal lightcurve and near 24 hours with trimodal lightcurve are completely ruled out because in both cases lightcurves on consecutive nights would be separated by an integer number of cycles and would look the same. An alternative interpretation, which was not considered by Harris and Young (1980), is that the period is near 32 hours with a quadrimodal lightcurve the two halves of which look the same. This interpretation would require a shape model symmetric over a 180 degree rotation, highly unlikely for a real asteroid but not absolutely impossible.

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. All exposures were 30 seconds, unguided, with a clear filter. Photometric measurement and lightcurve construction are 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 minutes between points in each bin.

New observations were made with three goals, first to resolve the near 16 hour versus 32 hour ambiguity, second to provide additional data for lightcurve inversion modeling, and third to further refine the 15.89 hour period reported by Harris and Young (1980). To obtain full phase coverage for lightcurves phased to both near 16 hours and 32 hours it is necessary to have sessions of at least 8 hours each night. Four consecutive nights will provide full phase coverage for both of these periods. Or, if any of these four nights is missed due to weather or other circumstance, the same part of the 32 hour lightcurve will be covered 4, or if necessary, 8 nights after the missed session. Four such sessions were obtained near 12 degrees phase angle 2013 Nov. 26-29. Five additional sessions 2013 Dec. 23 - 2014 Jan. 2 at phase angle between 3 and 5 degrees also provide full phase coverage for a trial period near 32 hours.

Separate lightcurves for an assumed period near 16 hours with bimodal lightcurve are drawn for the Nov. 26-29 data, Dec. 23-Jan. 2 data, and for the entire data set. A rotation period 15.853 ± 0.001 hours with amplitude 0.22 ± 0.01 magnitudes provides a good fit to the composite lightcurve. This period I interpret as the most accurate yet obtained. Inspection of the composite lightcurve shows that the shape of lightcurve changed significantly between 12 degrees and 3 degrees phase angle. For each of the short interval data sets lightcurves separated by 2, 6, or 10 nights looks identical within photometric accuracy of the equipment.

Therefore for a suggested period slightly less than 32 hours the two halves of the lightcurve look identical for three different observational geometries. The probability that a shape model could be symmetric over a 180 degree rotation in all three geometries becomes exceedingly small indeed. I conclude that a period slightly less than 32 hours may be confidently rejected, and that the 15.853 hour period found in this study may be considered secure.

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