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763 CUPIDO: A TUMBLING ASTEROID

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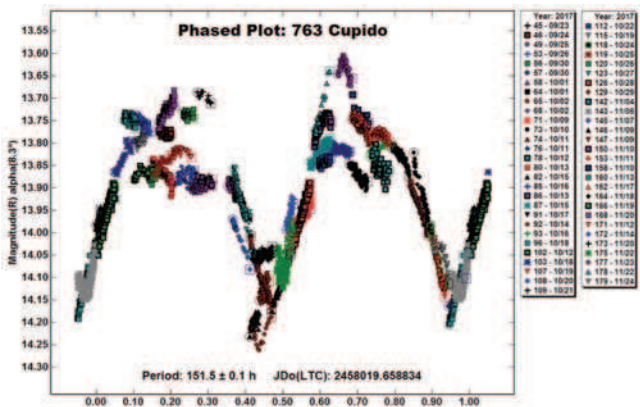
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We find that 763 Cupido is a tumbling asteroid with a principal period near 151.5 h, amplitude 0.45 ± 0.10 mag. The second period is too close to being commensurate with the principal period to be reliably found. Possible periods may be near 101 hours (2/3 of the principal period), or 121 hours (4/5 of the principal period).

The only previously published period of 763 Cupido is a very uncertain 14.88 h with amplitude 0.03 mag (Behrend, 2005). Pilcher initiated a more comprehensive investigation on 2017 Sep 23. By mid-October, a principal period near 152 hours with large discordances suggesting tumbling behavior became apparent. Pilcher then invited Benishek, Klinglesmith, and Odden et al. to collaborate. Petr Pravec (personal communication) used simultaneous dual period software to confirm tumbling, but the second tumbling period was close to being commensurate with



152 hours and could not be found reliably. We continued observations until 2017 Nov 24, at which time a total of 10526 data points had been acquired in 57 sessions. Pravec (personal communication) used the simultaneous dual period software with the expanded data set. A principal period near 151 h with tumbling was confirmed, $PAR = -2$ (Pravec et al., 2005). Due to the previously mentioned commensurability, the second tumbling period still could not be obtained reliably, with possible periods near 101 h (2/3 of principal period) or near 121 h (4/5 of principal period). We present a single period lightcurve plotted by *MPO Canopus* that provides a best fit to 151.5 h with amplitude 0.45 ± 0.10 mag. The lightcurve was plotted with target magnitudes calibrated from R band magnitudes of solar-colored stars on the Carlsbad Meridian Catalog 15 (CMC15) with no adjustments. Star magnitudes in the CMC15 catalog are usually consistent across the sky within 0.05 magnitudes. Occasional larger discrepancies occur. Still further magnitude discordances may arise from differences in the optical paths and CCD sensors of the several contributing observatories. It is not possible to determine to what extent magnitude discrepancies on the lightcurve are due to these instrumental and calibration effects and which are caused by different presented target cross sections at different phases of the tumbling cycle. On this lightcurve, the large data set has been binned in subsets of 3 data points with a maximum time difference between each point of 5 minutes.

Number	Name	2017/mm/dd	Pts	Phase	LPAB	BPAB	Period(h)	P.E	Amp	A.E.
763	Cupido	09/23-11/24	10526	8.3, 4.7, 26.0	13	6	151.5	0.1	0.45	0.10

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date, unless a minimum (second value) was reached. LPAB and BPAB are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984).

Acknowledgments

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Editor's Note: The broad collaboration and cooperation of this observer team, bringing forth such an interesting result, is a cause for celebration. Bravo !

LIGHTCURVE ANALYSIS FOR SEVEN MAIN-BELT ASTEROIDS

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Synodic rotation periods were determined for seven main-belt asteroids: 763 Cupido, 151.1 ± 0.1 h; 882 Svetlana, 29.867 ± 0.009 h; 916 America, 37.294 ± 0.013 h; 920 Rogeria, 12.244 ± 0.003 h; 1182 Ilona, 29.8553 ± 0.0023 h; 1283 Komsomolia, 32.175 ± 0.005 h; and 1639 Bower, 22.181 ± 0.003 h. All the data have submitted to the ALCDEF database.

CCD photometric observations of seven main-belt asteroids having long periods were performed at Command Module Observatory (MPC V02) in Tempe. Images at V02 were taken using a 0.32-m *f*/6.7 Modified Dall-Kirkham telescope, SBIG STXL-6303 CCD camera, and a 'clear' glass filter. Exposure times for all the images were 2 minutes. The image scale after 2x2 binning was 1.76 arcsec/pixel. Table I shows the observing circumstances and results.

Images were calibrated using a dozen bias, dark, and flat frames. Flat-field images were made using an electroluminescent panel.

The data reduction and period analysis were done using *MPO Canopus* (Warner, 2017). The 45x30 arcmin field of the CCD typically enables the use of the same field center for three

consecutive nights. In these fields, the asteroid and three to five comparison stars were measured. Comparison stars were selected with colors within the range of $0.5 < B-V < 0.95$ to correspond with color ranges of asteroids. In order to reduce the internal scatter in the data, the brightest stars of appropriate color that had peak ADU counts below the range where chip response becomes nonlinear were selected. The *MPO Canopus* internal star catalogue was useful in selecting comp stars of suitable color and brightness.

Comp star magnitudes were derived from a combination of CMC15 (Muñoz et al. 2014), APASS DR9 (Munari et al. 2015), and GAIA1 G (Sloan $r' = G + 0.066$ for stars of asteroidal color) catalogues to set the zero-points each night. In most regions the Sloan r' data sources for brighter stars yielded very similar magnitudes (within about 0.05 mag total range), so mean values rounded to 0.01 mag precision were used.

This careful adjustment of the comp star magnitudes and color-indices allowed the separate nightly runs to be linked often with no zero-point offset required, or shifts of only a few hundredths of a magnitude in a series.

A 9-pixel (16 arcsec) diameter measuring aperture was used for asteroids and comp stars. It was typically necessary to employ star subtraction to remove contamination by field stars. For the asteroids described here, I note the RMS scatter on the phased lightcurves, which gives an indication of the overall data quality including errors from the calibration of the frames, measurement of the comp stars, the asteroid itself, and the actual period-fit. Period determination was done using the *MPO Canopus* Fourier-type FALC fitting method (cf. Harris et al., 1989).

The Asteroid Lightcurve Database (LCDB; Warner et al., 2009) was consulted to locate previously published results. All of the new data for these seven asteroids may be found in the ALCDEF (<http://alcdef.org>) database.

763 Cupido is a Flora-family asteroid that was discovered in 1917 by Franz Kaiser at Heidelberg. The only reported period is that of Behrend (2005), who computed 14.88 h based on limited observations. Using an exhaustive data set, Pilcher et al. (2018, this issue) found a period of 151.5 h, with tumbling confirmed.

A total of 717 observations on 11 nights were obtained. A period spectrum between 100 h and 200 h revealed a solution at 151.1 ± 0.1 h, in good agreement with the result of Pilcher et al. The amplitude is 0.24 ± 0.02 mag and the RMS error on the fit is 0.024 mag.

