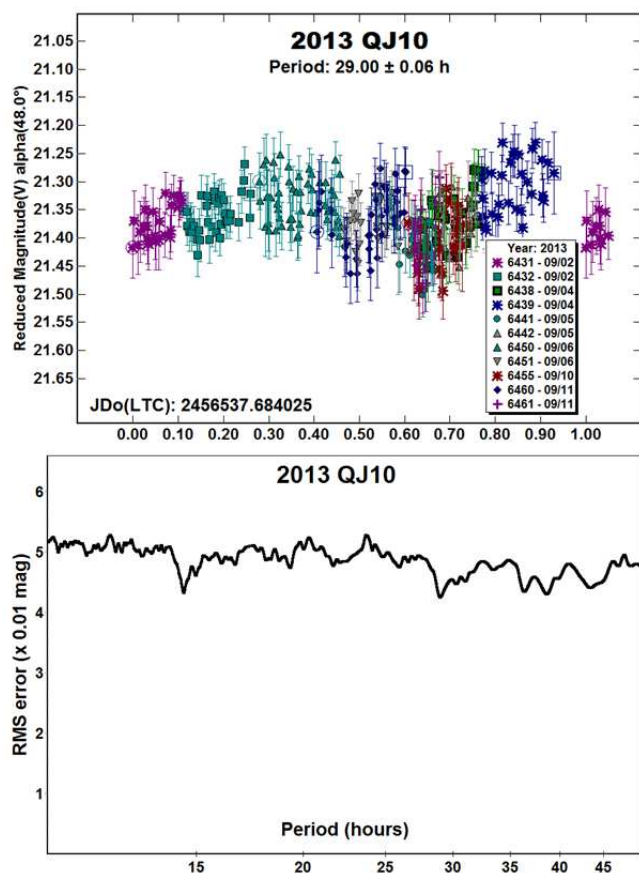




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ROTATION PERIOD DETERMINATIONS FOR 205 MARTHA AND 482 PETRINA

Frederick Pilcher
4438 Organ Mesa Loop
Las Cruces, NM 88011 USA
pilcher@ic.edu

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The synodic rotation periods and amplitudes for two asteroids are reported: 205 Martha, 14.905 ± 0.001 h, amplitude ranging from 0.21 to 0.14 magnitudes; and 482 Petrina, 11.7922 ± 0.0001 h, $A = 0.53 \pm 0.05$ mag. The changes in the lightcurve of 205 Martha in the interval 2013 Aug. 2 - Oct. 2 are documented.

Observations to determine the lightcurve parameters for 205 Martha and 482 Petrina were made at the Organ Mesa Observatory with a 0.35-meter Meade LX200 GPS Schmidt-Cassegrain (SCT) and SBIG STL-1001-E CCD. Photometric measurement and lightcurve construction are with *MPO Canopus* software. All exposures were 60 seconds, unguided, and used a clear filter. 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 consecutive points in each bin.

205 Martha. Previous efforts to find the period for this asteroid have yielded many different values, all of them being close to commensurate with an Earth day. This is especially likely to yield a convincing but incorrect alias period. These periods, and their approximate fractions of the Earth's period, are: Behrend (2003), 11.899 hours, 1/2; Behrend (2004), 11.92 hours, 1/2; Behrend (2007), 11.92 hours, 1/2; Chiorny *et al.* (2007), 9.78 hours, 2/5; Hawkins and Ditteon (2008), 9.74 hours, 2/5; Warner (2010), 39.8 hours, 5/3; Saylor and Leake (2012), 11.8 hours, 1/2; and Stephens and Warner (2012), 14.912 hours, 3/5, who also found the data

published in Warner (2010) compatible with a period of 14.93 hours.

New observations were made on 13 nights from 2013 Aug. 2 to Oct. 2. During this interval, the lightcurve changed appreciably. A subset of five sessions from Aug. 2-6 near phase angle 19 degrees provides a good fit to a lightcurve phased to 14.891 ± 0.005 h with an amplitude 0.21 ± 0.02 mag. Another subset of five sessions from Sept. 24 - Oct. 2 near phase angle 3 degrees provides a good fit to a lightcurve phased to 14.911 ± 0.002 h with an amplitude of 0.14 ± 0.01 mag.

Each of these subsets was phased to its respective double period and each provides a lightcurve for which the two halves are the same within reasonable errors of observation. A shape model highly symmetric over a 180 degree rotation is required to provide these symmetric lightcurves. That the two halves furthermore change by the same amount requires even higher symmetry. The probability that a real asteroid could have a shape as symmetric as this assumption requires is extremely small and may be safely rejected. A period spectrum was drawn between 5 and 45 hours to include all previously suggested periods. The two minima near 14.9 and 29.8 hours, respectively, were much lower than any other minima. Trial lightcurves phased to all other minima were drawn and all showed large misfits. Therefore, it seems a period near 14.9 hours is secure.

A lightcurve drawn for all 13 sessions from 2013 Aug. 2 - Oct. 2 provides the best fit to a period 14.905 ± 0.001 h. The changes in the lightcurve shape are clearly shown. Those individual sessions following Aug. 6 and preceding Sept. 24 have lightcurves whose amplitudes are intermediate between those of Aug. 2-6 and Sept. 24 - Oct. 2 as described above.

482 Petrina. Previous rotation period and amplitude determinations for 482 Petrina all obtained different results and, as for 205 Martha, were close to being commensurate with an Earth day. The periods, approximate fraction of Earth's period, amplitude, and approximate ecliptic longitudes at which they were found are: Behrend (2002), a very uncertain 18 hours, 3/4, with a single four-hour lightcurve showing an amplitude >0.13 magnitude, 310 degrees; Buchheim (2007), 15.73 hours, 2/3, 0.48 magnitude, 184 degrees; Stephens (2009), 9.434 hours, 2/5, 0.06 magnitude, 295 degrees; and Pilcher *et al.* (2012), 11.794 hours, 1/2, 268 degrees, 0.10 magnitude, who also claimed that the lightcurves by Buchheim (2007) and Stephens (2009) were compatible with their 11.794 hour period.

Pilcher *et al.* (2012) used the amplitude-aspect relationship to suggest that the rotational pole was fairly close to the orbital plane and with a longitude of about 280 degrees, or between longitudes of the Stephens (2009) and Pilcher *et al.* (2012) small amplitude observations. This model predicts that the viewing aspect, near ecliptic longitude 9 degrees at the 2013 apparition, would be close to equatorial. If the prediction were correct, the amplitude would be nearly the maximum possible. In addition, the period would be 11.794 ± 0.01 h and the amplitude within a few hundredths magnitude of the 0.48 magnitudes reported by Buchheim (2007), whose observations were at 184 degrees. Only the JD of lightcurve minimum was completely unknown.

Analysis of observations on eight nights between 2013 Aug. 7 and Oct. 3 are fully compatible with this prediction and allow confidence in the spin model. They provide a good fit to a lightcurve with period 11.7922 ± 0.0001 h, amplitude 0.53 ± 0.05 mag. All other suggested periods are now definitively ruled out.

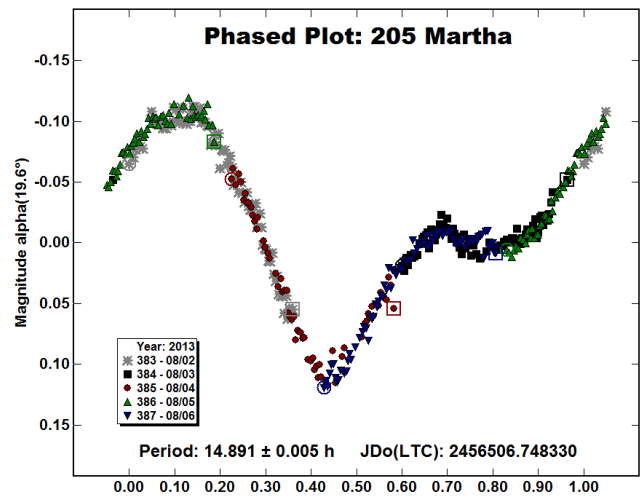


Figure 1. Lightcurve of 205 Martha for the interval 2013 Aug. 2-6.

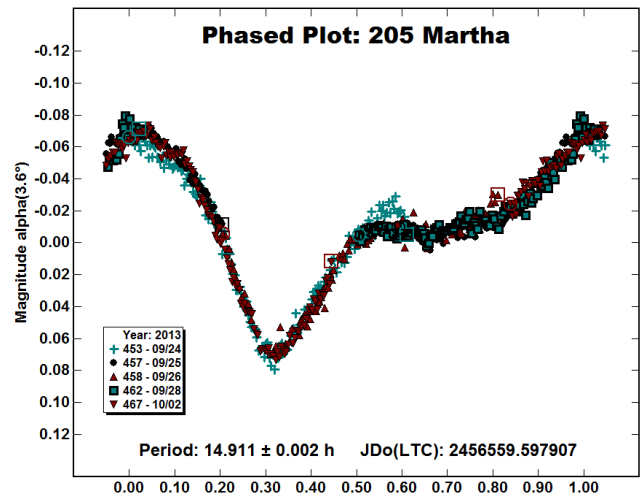


Figure 2. Lightcurve of 205 Martha for the interval 2013 Sept. 24 - Oct. 2.

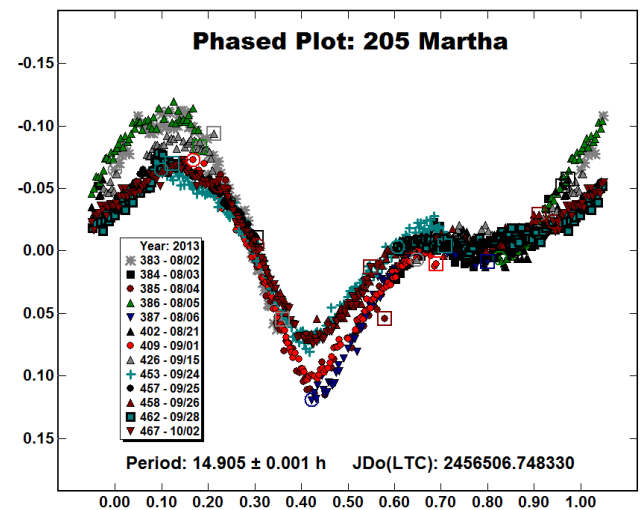


Figure 3. Lightcurve of 205 Martha for the interval 2013 Aug. 2 - Oct. 2.

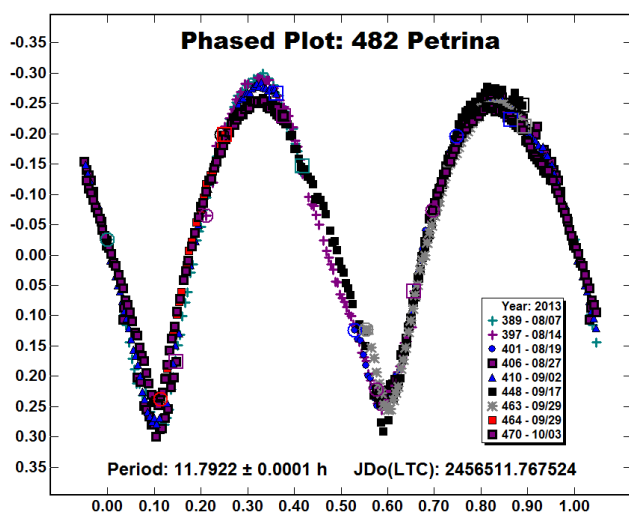


Figure 4. Lightcurve of 482 Petrina.

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SPINS, LIGHTCURVES, AND BINARITY OF EIGHT ASTEROID PAIRS: 4905, 7745, 8306, 16815, 17288, 26416, 42946, AND 74096

David Polishook

Department of Earth, Atmospheric, and Planetary Science
Massachusetts Institute of Technology, Cambridge MA 02139
davidpol@mit.edu

(Received: 15 October Revised: 11 November)

Asteroid pairs are two asteroids found to share almost identical orbital elements. Studies have shown that each pair had a single progenitor that split in the last couple of million years due to rotational-fission of a 'rubble-pile' structured body. Here we report the lightcurves and spins of eight primary members of asteroid pairs observed at the Wise Observatory in Israel. The lightcurves of two of the observed asteroids present light attenuation in addition to the standard periodicity; these are most probably the results of satellites causing mutual events of eclipse and occultation.

Pairs of asteroids move about the Sun on very similar orbits (Vokrouhlický and Nesvorný, 2008), but are gravitationally unbound to each other as opposed to a related class of binary asteroids. Using backward integration it was shown that members of each pair were in the same location in space at a certain time within the past couple of million years (Pravec *et al.*, 2010). This suggests a common origin for the components of each pair. Indeed, spectroscopic observations and broadband photometry studies have shown that members of observed pairs have similar spectra or colors (Moskovitz, 2012).

Photometric measurements (Pravec *et al.*, 2010) showed that rotation periods of the larger members of asteroid pairs are correlated with the mass ratio in a way that matches the rotational-fission mechanism (Fig. 1): (i) if the secondary (the smaller member) is massive enough, it carries a significant amount of angular momentum and the rotation rate of the primary (the larger member) will decelerate; (ii) if the secondary is not massive, the primary will continue to rotate fast. Therefore, it is accepted that each pair was formed by a fast rotating asteroid that split into two objects.

Method

The observations took place on 17 nights between 2011 and 2013. Observations were performed using the 0.46-m Centurion telescope (Brosch *et al.*, 2008) of the Wise Observatory (MPC 097). The telescope was used with an SBIG STL-6303E CCD. This CCD has an array of 3072x2048 pixels and covers a wide field-of-view of 75x50 arcmin with a scale of 1.47 arcsec/pixel, unbinned. On 2011 April 1 and 2, and on 2013 October 28, Wise Observatory's 1-m telescope was used with a PI CCD. This CCD with its array of 1340x1300 pixels covers a field-of-view of 13x13 arcmin; the plate scale is 0.58 arcsec/pixel, unbinned. Observations were performed in "white light" with no filters (Clear). The asteroids were observed while crossing a single field, thus the same comparison stars were used to calibrate the images. See observational circumstances in Table I.

The images were reduced in a standard way. IRAF's *phot* function was used for the photometric measurements. After measuring, the photometric values were calibrated to a differential magnitude