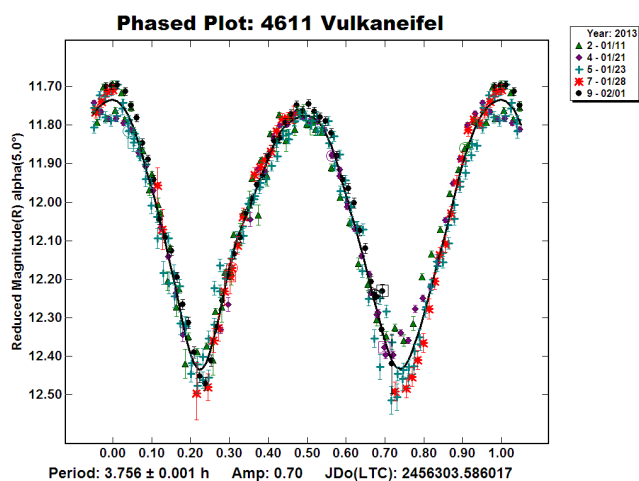


its rotation period and lightcurve amplitude.

Observations at the Phillips Academy Observatory were conducted with a 0.4-m f/8 DFM Engineering telescope using an SBIG 1301-E CCD camera with a 1280 x 1024 array of 16-micron pixels. The resulting image scale was 1.0 arcsecond per pixel. Exposures were 240 s working at -35° C. All images were dark and flat field corrected, guided, unfiltered, and unbinned. Images were measured using *MPO Canopus* (Bdw Publishing) with a differential photometry technique. Data merging and period analysis was done within *MPO Canopus* using an implementation of the Fourier analysis algorithm of Harris *et al.* (1989).

The data were analyzed by all listed authors, with E. Carrolo and G. Freund producing the lightcurve below. They determined a best fit of 3.756 ± 0.001 h with amplitude of 0.70 ± 0.05 mag. The final data set contained 334 points. This period agrees with the results of Hanus *et al* in their analysis of 4611 Vulkaneifel and other minor planets using Catalina Sky Survey data.



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ROTATION PERIOD DETERMINATIONS FOR 102 MIRIAM, 108 HECUBA, 221 EOS, 255 OPPAVIA, AND 745 MAURITIA, AND A NOTE ON 871 AMNERIS

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Synodic rotation periods and amplitudes have been found for 102 Miriam 23.625 ± 0.001 hours, 0.08 ± 0.01 magnitudes; 108 Hecuba 14.256 ± 0.001 hours, 0.12 ± 0.02 magnitudes; 221 Eos 10.443 ± 0.001 hours, 0.08 ± 0.01 magnitudes; 255 Oppavia 19.499 ± 0.001 hours, 0.16 ± 0.02 magnitudes with 3 unequal maxima and minima per cycle; 745 Mauritia 9.945 ± 0.001 hours, 0.12 ± 0.02 magnitudes. For 871 Amneris observations on 2 consecutive nights suggest a rotation period of several days with amplitude > 0.35 magnitudes.

Observations to produce these determinations have been made at the Organ Mesa Observatory with a 35.4 cm Meade LX200 GPS S-C and SBIG STL 1001-E CCD. Photometric measurement and lightcurve construction are with *MPO Canopus* software. All exposures are 60 second exposure time, unguided, 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 maximum time difference 5 minutes. In all cases the lightcurve of the double period has been examined and shows complete or nearly complete phase coverage with the two halves almost the same, and may be safely rejected.

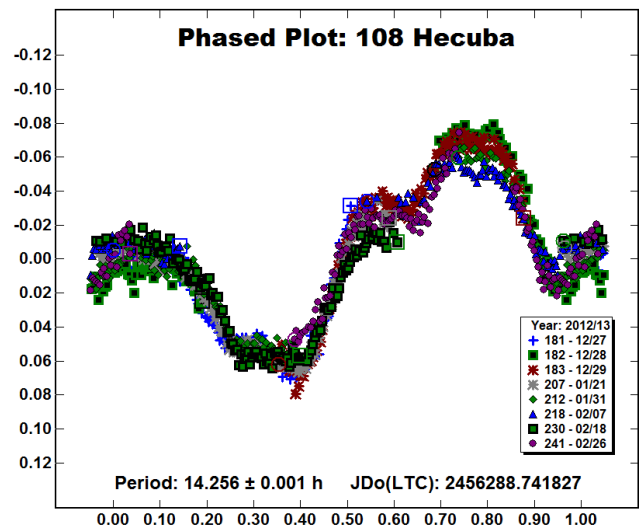
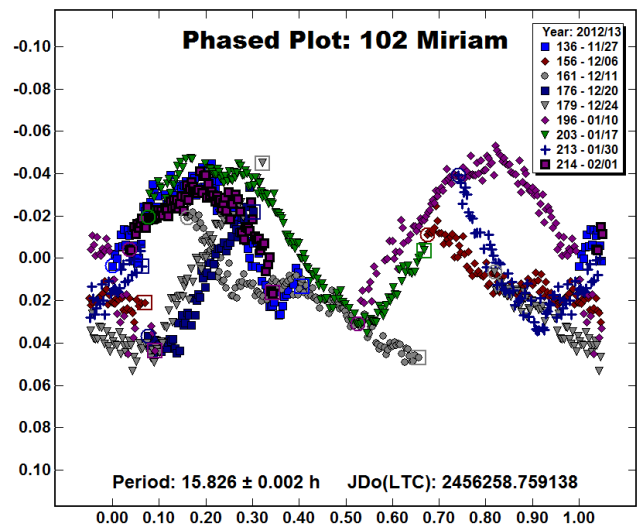
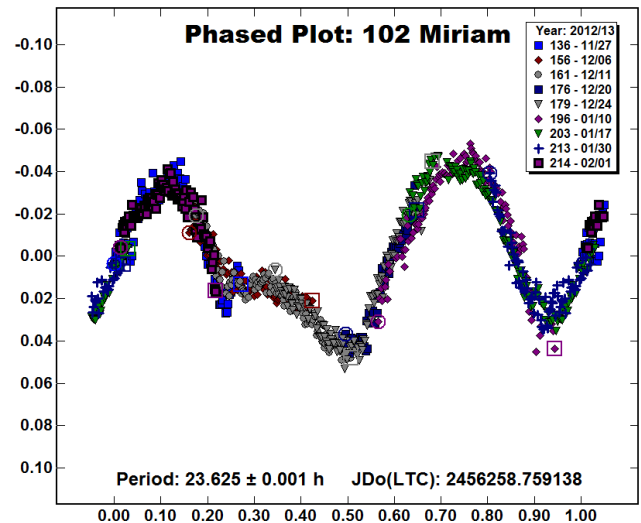
102 Miriam. Previous period determinations are by Shevchenko et al. (1997), 15.789 hours; Riccioli et al. (2001), 15.853 hours; Johnson et al. (2008) 15.789 hours; all providing lightcurves with the usual 2 maxima and minima per cycle; and this writer (Pilcher, 2008), 23.613 hours with 3 unequal maxima and minima per cycle and who also claimed a period near 15.8 hours was ruled out. All of these results were obtained near ecliptic longitude 25 degrees. New observations near ecliptic longitude 120 degrees were planned with the specific goal of unambiguously distinguishing between periods near 15.8 hours and 23.6 hours. All of these claimed periods are slightly less than Earth commensurate, and the segment of lightcurve observed from a single location circulates slowly to the right, with about 60 days required for a complete circulation. Therefore observations were continued from 2012 Nov. 27 to 2013 Feb. 1, and to investigate both sides of a lightcurve phased to a suggested period near 15.8 hours the interval between successive sessions was set to an odd number of days. The new observations on 9 nights are definitive. They

provide a good fit to a lightcurve phased to 23.625 ± 0.001 hours with amplitude 0.08 ± 0.01 magnitudes. This is compatible with the 23.613 hours obtained near ecliptic longitude 25 degrees and again absolutely rules out a period near 15.8 hours. It is noteworthy that while the lightcurve of 102 Miriam has 3 maxima and minima per cycle near ecliptic longitude 25 degrees, it has near ecliptic longitude 120 degrees the usual two maxima and minima per cycle.

It is instructive to note that all preceding lightcurves are compatible with a period near 23.6 hours, and to explain how acceptance of the 15.8 hour period persisted for many years. As explained previously observations must be continued for at least 60 days to cover the entire lightcurve. Prior to the current investigation all observations had been made within 10 degrees of ecliptic longitude 25 degrees, where 102 Miriam is near perihelion and at its brightest. Hence corresponding sections of the lightcurve included in the data sets should look the same. Pilcher (2008), with 8 sessions 2007 Sept. 14 – Nov. 19, was the first to cover the complete circulation. This lightcurve shows three similar maxima, two similar minima, and one minimum much deeper than the others. While careful examination reveals small but distinct differences among these 3 maxima and the two similar minima, they could easily be overlooked by someone expecting a bimodal lightcurve. Shevchenko et al. (1997) obtained 11 sessions 1974 Sept. 20.2 to Oct. 30.0. In most cases this would be sufficient to cover the entire lightcurve. But in this case given the rate of circulation this observation set covered only about 2/3 of the total lightcurve. It is suggested, but cannot be proved with data currently available, that the single deep minimum that would have revealed the 23.6 hour period was the segment that was not covered. Riccioli et al. (2001) present a highly symmetric bimodal lightcurve based on observations on 7 nights 1994 Oct. 26 – Nov. 3 which fit a period 15.853 ± 0.002 hours with amplitude 0.08 magnitudes. No one session exceeded 6 hours. Such a symmetric lightcurve could be interpreted in terms of a period near 7.9 hours or 23.6 hours. In both cases the same maximum would be observed on all nights, which explains the observed symmetry. Indeed it is rare that a true bimodal lightcurve exhibits this high degree of symmetry. There are now many published examples of reliable rotation periods based on lightcurves with fairly small amplitude and only one maximum and minimum per cycle. Anyone obtaining a symmetric bimodal lightcurve of small amplitude should immediately suspect the period is only half as great as the bimodal lightcurve suggests. In the case of 102 Miriam the period turned out to be 3/2 as great as suggested by a bimodal lightcurve. Johnson et al. (2008) obtained sessions on only 3 nights 2007 Oct. 18, 19, 20. These overlap in time, and from an observatory with terrestrial longitude not far removed, the more extensive data set by Pilcher (2008). The Johnson et al. (2008) lightcurve could be fit at least as well to a period of 3/2 of their 15.789 hours, and their included segment corresponds well with the segment of Pilcher's lightcurve obtained on Oct. 19.

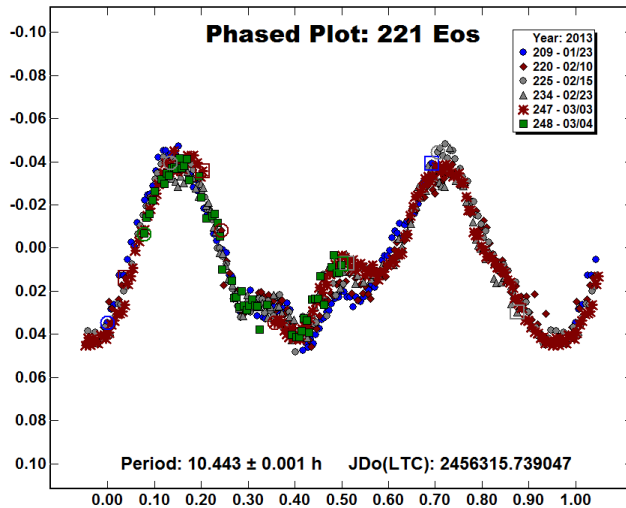
A lightcurve of the new data phased to a period near 15.8 hours shows a complete misfit and again rules out the shorter period.

108 Hecuba. Previous period determinations are by Behrend (2005), 19.8 hours; Blanco et al. (1994), 14.46 hours; and Warner (2007), 17.859 hours. New observations on 8 nights 2012 Dec. 27 – 2013 Feb. 26 provide a good fit to a lightcurve with period 14.256 ± 0.001 hours and amplitude 0.12 ± 0.02 magnitudes. The period spectrum shows no significant minima between 12 and 22 hours except at 14.256 hours. Among the previous period determinations this is consistent only with the 14.46 hours by Blanco et al. (1994).

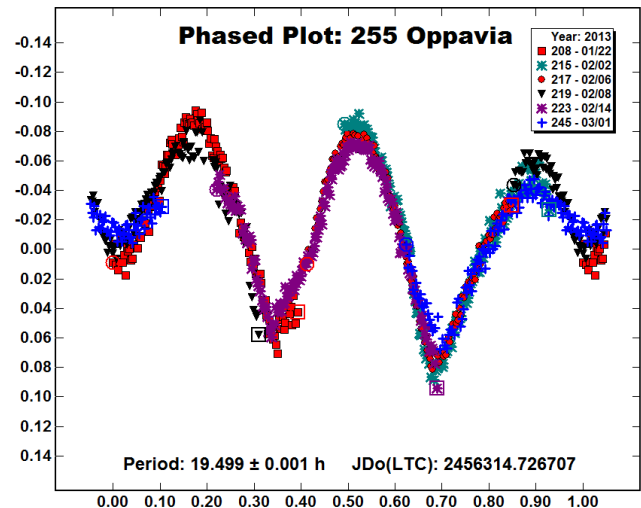


221 Eos. Previous period determinations are by Behrend (2007), 20.4 hours; Harris and Young (1980), 10.45 hours; and Harris and Young (1983), 10.436 hours. New observations on 6 nights 2013 Jan. 23 – Mar. 4 provide a good fit to a lightcurve with period 10.443 ± 0.001 hours and amplitude 0.08 ± 0.01 magnitudes. This period is consistent with Harris and Young (1980 and 1983), and

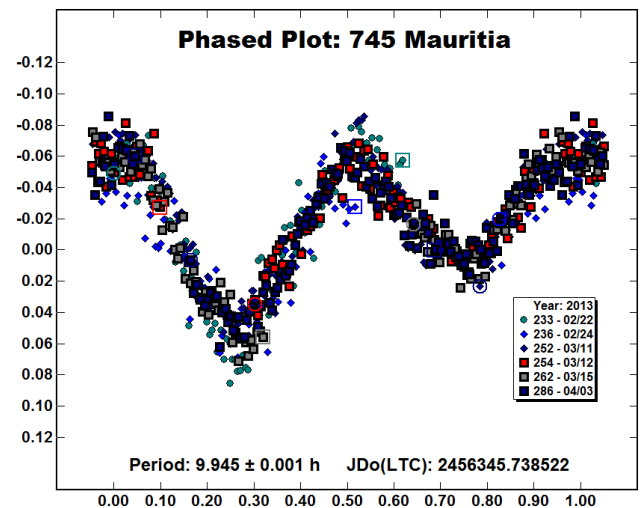
not with Behrend (2013). A bump in the rising part of the lightcurve near phase 0.50 became larger through the interval of observation from phase angle 13 degrees Jan. 23 to 2 degrees Mar. 4. Careful inspection of the lightcurve shows that this increase occurred steadily throughout the well-spaced set of observations. The two halves of a trial lightcurve phased to the double period of 20.866 hours displayed both the bump and its height increase over time in a highly symmetrical manner. It would require a very high degree of symmetry in the asteroid shape over a 180 degree rotation to produce such a feature which was not only an irregularity but one which changed uniformly with change in phase angle. The probability of such shape symmetry in a real asteroid is extremely small, and the double period may be confidently rejected.



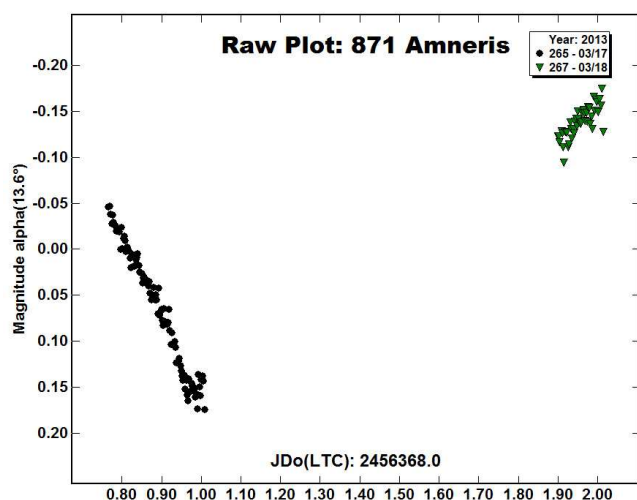
255 Oppavia. Previous period determinations are by Behrend (2008), 14.3 hours; and Ditteon et al. (2010), 19.57 hours. New observations on 6 nights 2013 Jan. 22 - Mar. 1 provide a good fit to a lightcurve phased to 19.499 ± 0.001 hours, amplitude 0.16 ± 0.02 magnitudes, and 3 unequal maxima and minima per cycle. An attempt to fit to a lightcurve with 2/3 of this period and the usual 2 maxima and minima per cycle provided a gross misfit, and the 2/3 period is definitively ruled out. Although this period disagrees with Behrend (2012), it is consistent with Ditteon et al. (2010). It is significant that the new data near ecliptic longitude 160 degrees produce a lightcurve with three maxima and minima per cycle while the much sparser set by Ditteon et al. (2010) near ecliptic longitude 220 degrees produce a lightcurve with two maxima and minima per cycle. This unusual behavior is also found for 102 Miriam as described previously



745 Mauritia. The Asteroid Lightcurve Data Base (Warner et al., 2012) shows no previous observations. New observations on 6 nights 2013 Feb. 22 - Apr. 3 provide a good fit to a lightcurve phased to 9.945 ± 0.001 hours and amplitude 0.12 ± 0.01 magnitudes.



871 Amneris. The Asteroid Lightcurve Data Base (Warner et al., 2012) shows no previous observations. New observations were made on consecutive nights of March 17 and 18. The 25 x 25 arcminute field of the SBIG STL-1001E CCD enabled the same two comparison stars to be used on both nights. Even if there are errors in their catalog magnitudes the calibrated asteroid magnitudes should be consistent. A raw lightcurve of the calibrated data suggests a rotation period of several days and an amplitude > 0.35 magnitudes. Such a target requires many sessions over a long time interval for its complete solution and it was decided to acquire no more data at the current apparition. The next favorable opposition occurs in early 2016 and a campaign involving an international collaboration of northern hemisphere observers is recommended at that time.



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THREE ASTEROIDS WITH CHANGING LIGHTCURVES: 12 VICTORIA, 177 IRMA, AND 215 OENONE

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During their early 2013 apparitions the lightcurve shape and inferred rotation period for 12 Victoria, 177 Irma, and 215 Oenone changed considerably. These changes are described and approximate synodic periods and amplitudes are derived: 12 Victoria 8.661 ± 0.001 hours, 0.05 ± 0.01 magnitudes; 177 Irma 13.858 ± 0.001 hours, 0.24 ± 0.02 magnitudes; 215 Oenone 27.93 ± 0.01 hours, 0.19 ± 0.02 magnitudes.

Asteroid lightcurves are not as highly repetitive as those of most variable stars. These changes are caused by changing phase angle and viewing aspect. Frequently these changes are not considered in producing composite lightcurves including all sessions on the observed object. Over intervals of 10 to 15 days they are usually sufficiently small to be scarcely detectable. Over intervals of 2 months or more they may be considerable, and provide important information for spin/shape modeling. In this paper I consider three cases for which a single asteroid showed an unusually great change in form of lightcurve. I present three lightcurves of each object, two over short time intervals during which the change was fairly small, and one covering the entire interval of observation. In interpreting the two shorter interval lightcurves we must recognize that these changes are occurring slowly and steadily throughout the apparition, and not that the lightcurve somehow changed suddenly between the first and second selected intervals. Careful examination of the shorter interval lightcurves does show detectable transition from the early interval shape to the later interval shape.

Observations to produce these determinations have been made at the Organ Mesa Observatory with a 35.4 cm Meade LX200 GPS S-C and SBIG STL 1001-E CCD. Photometric measurement and lightcurve construction are with *MPO Canopus* software. All exposures are 60 second exposure time, unguided, R filter for the bright object 12 Victoria and clear filter for much fainter 177 Irma and 215 Oenone. 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 maximum time difference 5 minutes.

12 Victoria. Warner et al. (2012) state a period of 8.6599 hours based on several independent and mutually compatible determinations. New lightcurves were obtained to contribute to improving a lightcurve inversion model. Four sessions 2013 Jan. 6 - Feb. 13 at phase angles 18 to 8 degrees provide a good fit to a lightcurve of period 8.6610 ± 0.0001 hours, amplitude 0.05 ± 0.01 magnitudes and shown in Figure 1. Three sessions 2013 Feb. 28 - Mar. 30 at phase angles 5 to 13 degrees provide a good fit to a lightcurve of period 8.6622 ± 0.0001 hours, amplitude 0.05 ± 0.01 magnitudes, shown in Figure 2. The changes in shape seem more closely related to before versus after opposition rather than to phase angle. A single lightcurve including all seven sessions (Figure 3) shows much greater variation among the sessions and a somewhat different derived period of 8.6607 hours. It is not clear which of these three periods should be accepted and somewhat conservatively I suggest a synodic period 8.661 ± 0.001 hours. This is fully compatible with previous determinations.