

PERIOD DETERMINATIONS FOR 11 PARTHENOPE, 35 LEUKOTHEA, 38 LEDA, 111 ATE, 194 PROKNE, 262 VALDA, 728 LEONISIS, AND 747 WINCHESTER

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Synodic rotation periods and amplitudes have been found for these asteroids: 11 Parthenope 13.722 ± 0.001 h, 0.11 ± 0.01 mag with one maximum and minimum per cycle; 35 Leukothea 31.900 ± 0.001 h, 0.42 ± 0.04 mag; 38 Leda 12.839 ± 0.001 h, 0.14 ± 0.02 mag; 111 Ate 22.072 ± 0.002 h, 0.09 ± 0.02 mag with an irregular lightcurve; 194 Prokne 15.677 ± 0.002 h, 0.08 ± 0.01 mag with one maximum and minimum per cycle; 262 Valda 17.386 ± 0.001 h, 0.17 ± 0.02 mag; 728 Leonis 5.5783 ± 0.0002 h, 0.20 ± 0.04 mag; 747 Winchester 9.414 ± 0.001 h, 0.18 ± 0.02 mag.

These reported observations were all obtained at the Organ Mesa Observatory. Equipment consists of a 35.4 cm Meade LX 200 GPS S-C and SBIG STL-1001E CCD, with unguided exposures through an R filter for 11 Parthenope and 111 Ate and clear filter for other targets, differential photometry only. Image measurement and lightcurve analysis were done with *MPO Canopus*. The lightcurves have been drawn with the large number of data points acquired for each target in this study binned in sets of three with a maximum of five minutes between points.

11 Parthenope. Until very recently every attempt at rotation period determination has produced a different result. All show low amplitude and complex lightcurves, for which alias periods are especially troublesome. In chronological sequence van Houten-Groeneveld and van Houten (1958) obtained an indefinite 10.7 hour period and 0.07 magnitude amplitude. Wood and Kuiper (1963) published an amplitude 0.12 magnitude and no period determination. Zappala (1983) obtained amplitude exceeding 0.07 mag and no period determination. Barucci et. al. (1985) found a period 7.83 hours, amplitude 0.08 mag. Melillo (1985) suggested a possible 5 hour period and 0.08 mag amplitude. Lang (1996) found amplitude 0.05 mag and possible period 11.75 hours. Piironen et. al. (1998) obtained a bimodal lightcurve of period 9.43 hours, amplitude 0.05 mag. Lang and Hansen (1999) obtained the first dense data set. It shows one narrow and one broad maximum, amplitude 0.10 mag, for which they claim a search of all possible periods from 5 hours to 2.3 days produced only one low residual fit at 13.720 hours. They also claim evidence for prograde rotation. Stephens et. al. (2008) obtained a period of 13.734 hours.

New observations at the Organ Mesa Observatory on 8 nights 2009 Nov. 28 – 2010 Jan. 17 show an irregular monomodal lightcurve with period 13.722 ± 0.001 hours, amplitude 0.11 ± 0.01 magnitudes. This is fully compatible with the dense data sets of Lang and Hansen (1999) and Stephens et. al. (2008). A period near 13.72 hours now seems to be well established.

35 Leukothea. All previous observations are consistent with a rotation period near 31.9 hours, and with greatly varying amplitude. Weidenschilling et. al. (1990) at longitude 87 degrees observed an amplitude of 0.38 magnitudes. Pilcher (2008)

obtained at longitudes 357 – 347 degrees an amplitude 0.07 ± 0.02 magnitudes. Lagerkvist et. al. (1987) show no variation beyond 0.02 magnitude scatter in a one hour run at longitude 249 degrees. Bernasconi, as presented by Behrend, (2008) obtained amplitude 0.38 ± 0.03 magnitudes near longitude 135 degrees. Pilcher and Jardine (2009) obtained near longitude 42 degrees an amplitude 0.08 ± 0.02 magnitudes. From a comparison of these amplitudes and the longitudes at which they were observed they concluded that a rotational pole was near longitude 17 degrees, latitude 0 degrees. The January, 2010 opposition at longitude 117 degrees provided an opportunity to obtain lightcurves at near equatorial aspect with obliquity near 90 degrees. Under this circumstance synodic and sidereal periods are nearly the same. Both of the previous data sets at near equatorial aspect covered only a short observation interval. This investigation on 10 nights over an interval of 75 days 2009 Dec. 3 – 2010 Feb. 16 obtains a synodic period 31.900 ± 0.001 hours, amplitude 0.42 ± 0.04 magnitudes. This is much closer to the sidereal rotation period than has been obtained with any previous study. The ratio a/b of maximum to minimum equatorial radii is found from $a/b \approx 10^{(0.4\Delta \text{Mag})}$. For $\Delta \text{Mag} = 0.42$ in the 2010 near equatorial aspect, a/b for 35 Leukothea is approximately 1.47. The ratio of minimum equatorial to polar radii b/c cannot be found from any data yet available.

Future studies. The rotation period is now known with sufficient accuracy to extrapolate the phase of any observation throughout any apparition. The rotational pole, as is commonly the case, has a bivalued solution, either longitude 17 degrees or 197 degrees. The next three oppositions, 2011 May 27, 2012 Sept. 3, 2013 Oct. 29, all occur fairly close to polar aspect. If at any of these there can be two moderately well observed occultations separated in time by an interval not close to an integer, half integer, or quarter integer number of rotational cycles, the change in orientation of the long axis will resolve the ambiguity of pole position. Alternatively, this goal can be achieved with disk resolved adaptive optics.

38 Leda. Previous period determinations are by De Young and Schmidt (1996), 12.84 hours; Wang and Shi (2002), 10.171 hours; and Pilcher (2009), 12.838 hours. New observations were made on 3 nights 2009 Nov. 19, 2010 Jan. 4, 9. Being few in number and widely separated in time, the data can be phased to several different periods with comparably good fit. Hence this investigation does not provide an independent period determination. The shortest of these periods, 12.839 ± 0.001 hours with amplitude 0.14 ± 0.02 magnitudes, is compatible with De Young and Schmidt (1996) and Pilcher (2009). The accompanying lightcurve is phased to this period. As is usually the case, there is considerable change in shape with greatly changing phase angle.

111 Ate. The only previous lightcurves are by Harris and Young (1983) who state a period 22.2 hours. New observations on 9 nights 2009 Nov. 21 – 2010 Jan. 16 show a period 22.072 ± 0.002 hours, amplitude 0.09 ± 0.02 magnitudes. An irregular lightcurve changed shape appreciably during the observation interval but the phases of the principal features remained nearly constant.

194 Prokne. Scaltriti and Zappala (1979) obtained absolute photometry at longitude 245 degrees, latitude +31 degrees, which included two well defined minima. No maximum was covered, but the amplitude is unlikely to be much larger than the maximum observed 0.27 magnitudes. They phased their data to a rotation period of 15.67 hours based on 60% coverage of a presumed bimodal lightcurve. New observations were obtained on 9 nights 2010 Jan. 30 – Mar. 19 at longitudes 174 to 164 degrees showing an amplitude only 0.08 ± 0.01 magnitudes. The most likely

interpretation is of a period 15.677 ± 0.002 hours with one maximum and minimum per cycle at a near polar aspect, and the accompanying lightcurve is phased to this period. This would imply the observations of Scaltriti and Zappala (1979) were at near equatorial aspect. The new observations and theirs constitute a consistent rotation model with a well defined period and approximate pole orientation within 30 degrees of longitude 170 degrees, latitude 2 degrees. The new data were also phased to periods two and three times as great with 2 and 3, respectively, maxima and minima per cycle. The multiple extrema on these had similar but not identical appearances. I consider these differences are very likely due to instrumental anomalies up to 0.02 magnitudes which are more prominent at low amplitude and to variations in the appearance of the lightcurve with greatly changing phase angle, rather to rotation periods of 31.356 or 47.039 hours. Furthermore the data of Scaltriti and Zappala (1979) can be phased to 31.356 or 47.039 hours only if their resulting lightcurve has four or six, respectively, maxima and minima per cycle. Their 0.27 magnitude amplitude seems unrealistically large for a lightcurve with such a large number of extrema per cycle.

262 Valda. The Asteroid Lightcurve Data Base (Harris et. al. 2009) shows no previous observations. Observations on 9 nights 2010 Jan. 24 – Mar. 4 show a period 17.386 ± 0.001 hours, amplitude 0.17 ± 0.02 magnitudes.

728 Leonis. The Asteroid Lightcurve Data Base (Harris et. al. 2009) shows no previous observations. Observations on 6 nights 2009 Dec. 27 – 2010 Feb. 1 show a period 5.5783 ± 0.0002 hours, amplitude 0.20 ± 0.04 magnitudes.

747 Winchester. The Asteroid Lightcurve Data Base (Harris et. al. 2009) shows period 9.4146 hours, reliability 3 (secure). Additional lightcurves were obtained to contribute toward a spin/shape model. Observations on 4 nights 2008 May 9 – 26 show a period 9.414 ± 0.001 hours, amplitude 0.18 ± 0.02 magnitudes, consistent with previous work.

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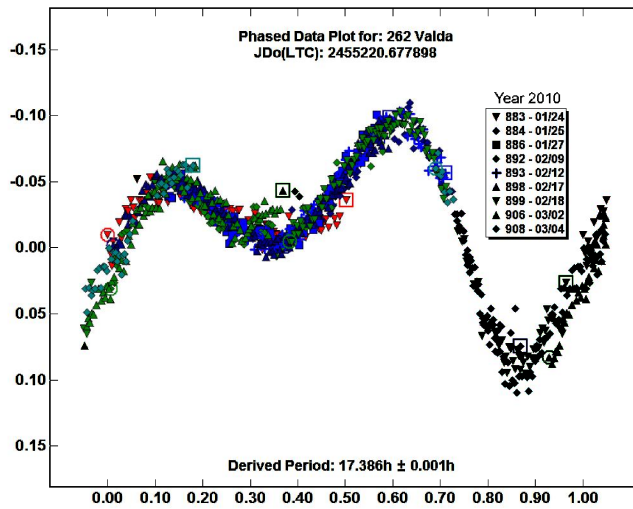
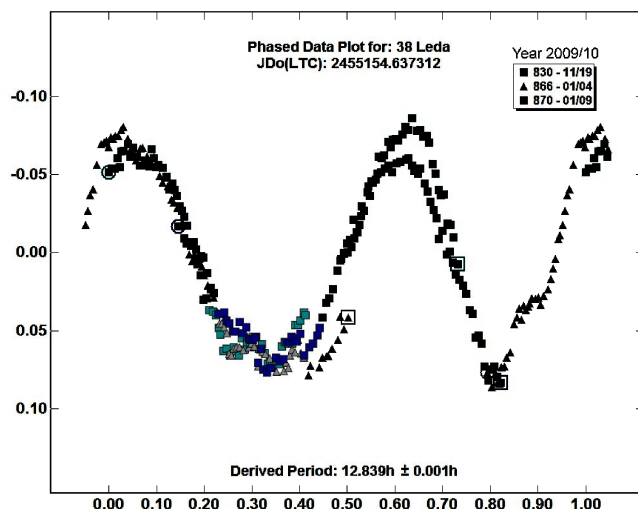
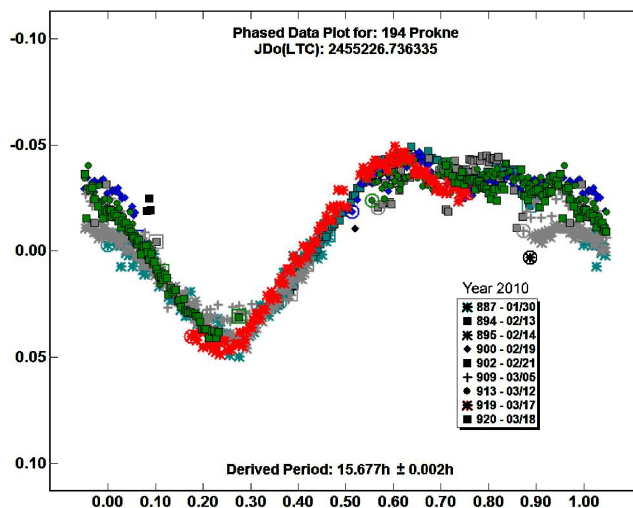
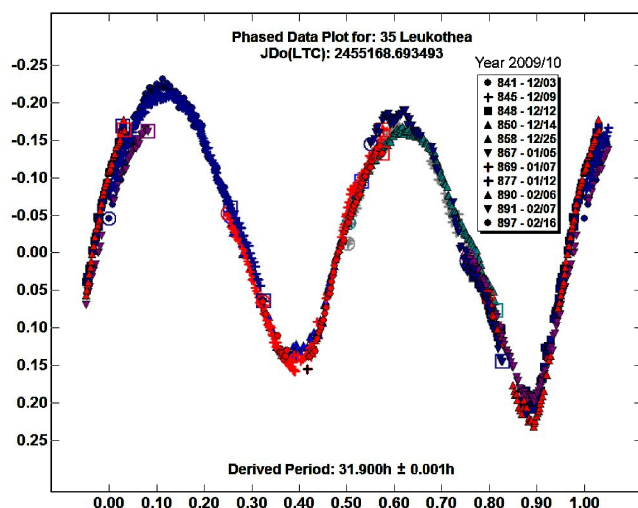
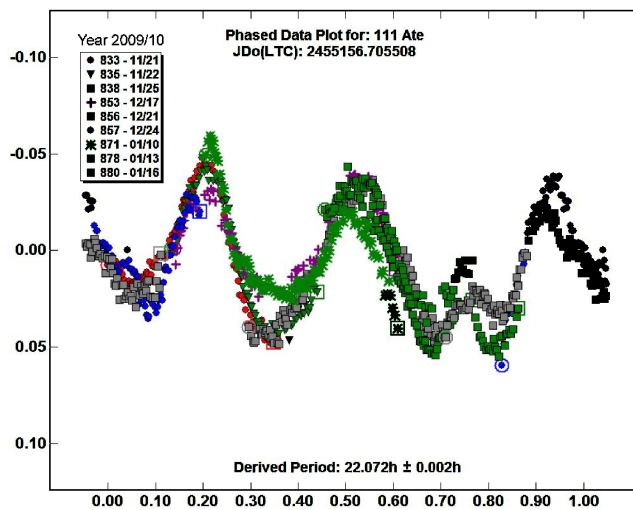
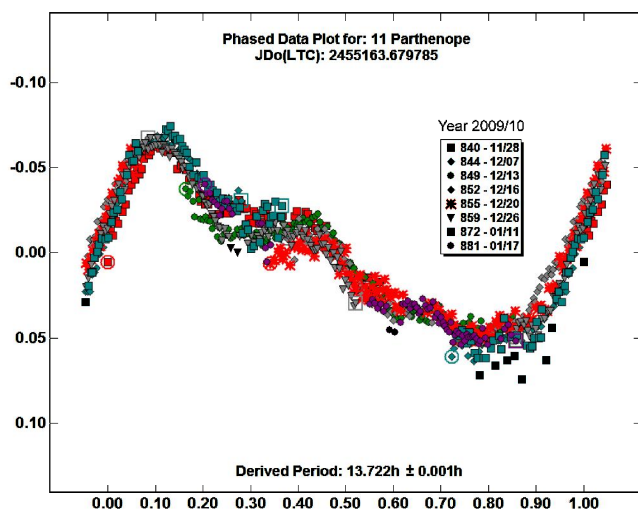
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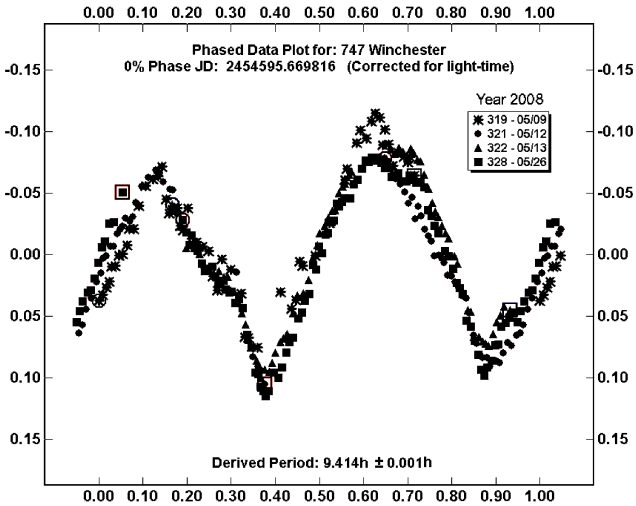
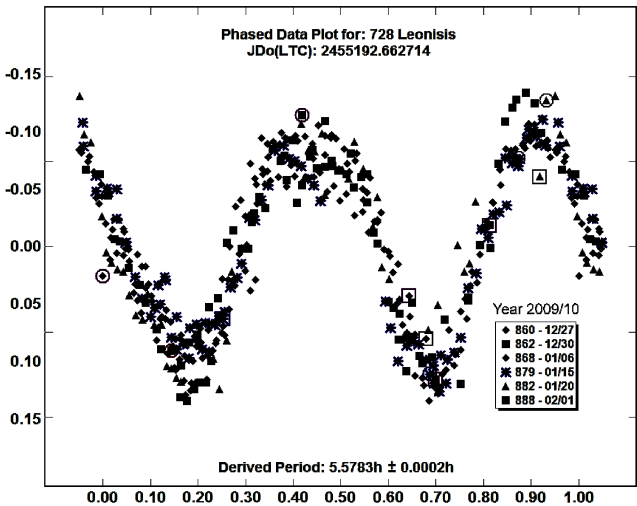
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**LIGHTCURVE ANALYSIS OF 581 TAUNTONIA,
776 BERBERICIA AND 968 PETUNIA**

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Results from Santana and GMARS Observatories over 2009 December to 2010 March are presented:
581 Tauntonia, $P=24.90 \pm 0.01$ h, $A=0.20$ mag.;
776 Berbericia, $P=7.67 \pm 0.01$ h, $A=0.12$ mag.;
968 Petunia, $P=61.280 \pm 0.005$ h, $A=0.40$ mag.

Unfiltered observations were made at Santana Observatory (MPC Code 646) were made with a 0.30-m Schmidt-Cassegrain (SCT) with a SBIG STL-1001E. Observations at GMARS (Goat Mountain Astronomical Research Station, MPC G79) were made with two telescopes, both 0.35-m SCT using SBIG STL-1001E CCD Cameras. All images were unguided and unbinned. Measurements were made using *MPO Canopus*, which employs differential aperture photometry to produce the raw data. Period analysis was done using *Canopus*, which incorporates the Fourier analysis algorithm (FALC; Harris 1989). Unless noted, the asteroids were selected from the list of asteroid photometry opportunities published on the Collaborative Asteroid Lightcurve Link (CALL) website (Warner et al. 2009).

The results are summarized in Table I, as are individual plots. The plots are “phased”, i.e., they range from 0.0 to 1.0 of the stated period. The plots are scaled such that 1.0 mag has the same linear size as the horizontal axis from 0.0 to 1.0. This is done to avoid the visual impression that the amplitude variation is greater than it actually is, which can create the impression of a physically implausible lightcurve. Night-to-night calibration of the data (generally $< \pm 0.05$ mag) was done using field stars converted to approximate Cousins R magnitudes based on 2MASS J-K colors (Warner 2007 and Stephens 2008).

581 Tauntonia. Observations were made on six nights spanning three weeks. Observations on 01/08, 01/11, and 01/24 were

obtained at Santana Observatory. All others were taken at GMARS. Behrend (2010) reported a single night of observations in June 2006 by Rene Roy with a period of 16.19 hours.

776 Berbericia. Berbericia is a well studied object selected as a Full Moon project to provide observations for additional future shape-model study. Durech et al. (2007) previously reported a shape model based upon observations from 1977 - 2006 while determining the period to be 7.66701 h.

968 Petunia. Wisniewski (1997) got a single night lightcurve fragment in 1992 but did not report a period. Behrend (2010) reported a single night of observations in April 2006 by Roberto Crippa with a period of approximately 10 hours. The observations on 12/19 and 01/03 were obtained at GMARS. All others were taken at Santana Observatory.

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	581 Tuantonía	776 Berbericia	968 Petunia
Dates	2010/01/08 – 2010/03/29	2009/12/15 – 2010/01/05	
Data Pts	1140	573	1584
α	1.5, 9.5	8.2	8.8, 9.2
Avg L_{PAB}	103	176	97
Avg B_{PAB}	1	22	-14
Per. (h)	24.90	7.67	61.280
PE (h)	0.01	0.01	0.005
Amp (mag)	0.20	0.12	0.40
AE (mag)	0.02	0.02	0.03

Table I. Observing circumstances.