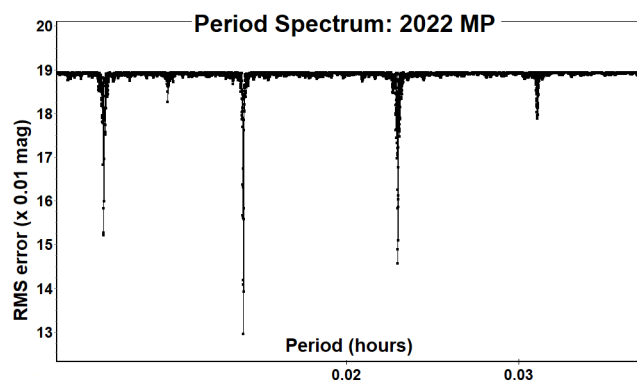




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LIGHTCURVES AND ROTATION PERIODS OF 233 ASTEROPE, 240 VANADIS, 275 SAPIENTIA, 282 CLORINDE, 414 LIRIOPE, AND 542 SUSANNA

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Synodic rotation periods and amplitudes are found for
233 Asterope 19.694 ± 0.001 h, 0.41 ± 0.02 mag;
240 Vanadis 10.565 ± 0.002 h, 0.07 ± 0.01 mag;
275 Sapienia 14.933 ± 0.001 h, 0.10 ± 0.01 mag;
282 Clorinde 49.350 ± 0.003 h, 0.19 ± 0.02 mag;
414 Liriope 11.009 ± 0.002 h, 0.14 ± 0.01 mag with 3
unsymmetrical maxima and minima per rotational cycle;
542 Susanna 10.089 ± 0.001 h, 0.09 ± 0.01 mag with 3
unsymmetrical maxima and minima per rotational cycle.

Observations to produce the results reported in this paper were made at the Organ Mesa Observatory with a Meade 35-cm LX200 GPS Schmidt-Cassegrain, SBIG STL-1001E CCD, 60 second exposures, unguided, R filter for 275 Sapienia, clear filter for all other targets. Image measurement and lightcurve construction were with *MPO Canopus* software with all calibration star magnitudes from the CMC15 catalog reduced to the Cousins R band. Zero-point adjustments of a few $\times 0.01$ magnitude were made for best fit. To reduce the number of data 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.

233 Asterope. Previously published periods are by Harris and Young (1983), 19.7 hours; Behrend (2012web), >10 hours; Piironen et al. (1998), 19.743 hours, all with moderately sparse lightcurves. New observations on six nights 2022 May 10 - June 6 provide an excellent fit to a period of 19.694 ± 0.001 hours, amplitude 0.41 ± 0.02 magnitudes (Fig. 1). This period is consistent with all previously published periods and with improved accuracy due to being based upon a much denser lightcurve.

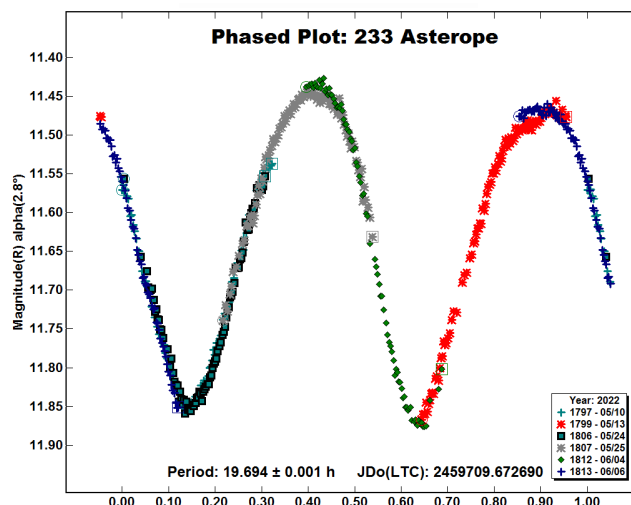


Figure 1. Lightcurve of 233 Asterope phased to 19.694 hours.

240 Vanadis. Previously published periods and amplitudes are by Denchev (2000), 10.64 hours, 0.34 magnitudes near celestial longitude 132° with an unsymmetric bimodal lightcurve; Behrend (2003web), > 12 hours, > 0.08 magnitudes based on a single 5-hour lightcurve; Alton (2016), 10.57 hours, 0.10 magnitudes near celestial longitude 68° with an irregular monomodal lightcurve.

New observations on 7 nights 2022 May 10 - June 1 near celestial longitude 235° provide an excellent fit to a monomodal lightcurve with period 10.565 ± 0.002 hours, amplitude 0.07 ± 0.01 magnitudes (Fig. 2). The split halves plot of the double period (Fig. 3) shows that the two halves are identical within observational error and rules out the double period. This value is consistent with Denchev (2000) and Alton (2016) and improves the accuracy with a longer interval of observation, 46 rotational cycles as compared with only three cycles in the study by Denchev (2000). The period by Behrend (2003web) is now ruled out.

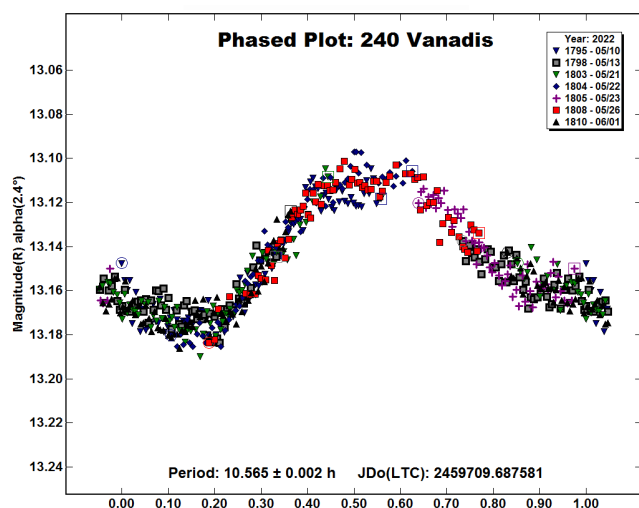


Figure 2. Lightcurve of 240 Vanadis phased to 10.565 hours.

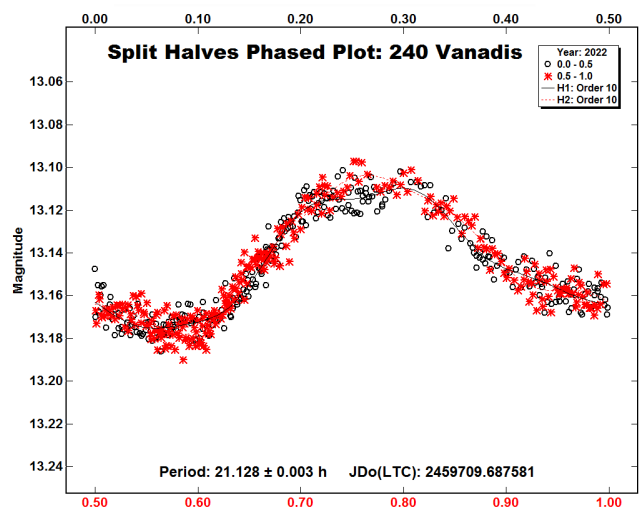


Figure 3. Split halves phased plot of 240 Vanadis.

The lightcurve published by Denchev (2000) constitutes a second line of evidence to rule out the double period. His lightcurve includes only two nights of data 1999 Jan. 21-22 but covers an entire 10.64-hour rotational cycle with an asymmetric bimodal lightcurve with maximum amplitude 0.34 magnitudes. No object with four maxima and minima per cycle and no albedo variegation can have an amplitude as great as 0.34 magnitude. Hence Denchev's data alone rule out a double period near 21.128 magnitudes.

The amplitude is much smaller at celestial longitudes 235° (this study) and at 68° (Alton, 2016) than at 132° (Denchev, 2000). The rotational pole is much closer to celestial longitude 235° than to celestial longitude 132° . Minor planet 240 Vanadis is another example of the commonly observed phenomenon that a minor planet with a bimodal lightcurve of moderately large amplitude at near equatorial aspect has a monomodal lightcurve of much smaller amplitude at near polar aspect.

275 Sapiientia. Previously published periods are by Denchev (2000), > 20 hours; Behrend (2005web), 24.07 hours; Kaminski et al. (2010), 9.5 hours; Pilcher (2015), 14.931 hours; Pilcher (2016), 14.932 hours; Warner (2007), 14.766 hours. New observations on 8 nights 2022/04/08 - 2022/05/19 provide an excellent fit to an irregular monomodal lightcurve with period 14.933 ± 0.001 hours, amplitude 0.10 ± 0.01 magnitudes (Fig. 4). A split halves plot of the double period (Fig. 5) shows excellent fit between the two halves of the plot. The double period is ruled out. The new data are compatible with Warner (2007), Pilcher (2015), and Pilcher (2016). All other published periods are now ruled out, and a period near 14.933 hours can be considered secure.

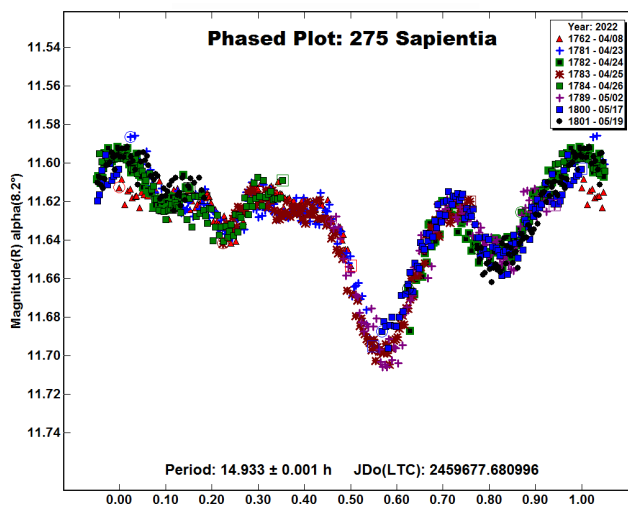


Figure 4. Lightcurve of 275 Sapiientia phased to 14.933 hours.

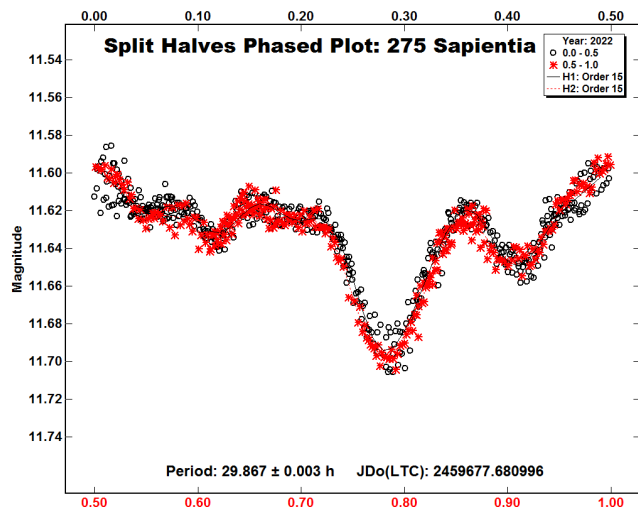


Figure 5. Split halves phased plot of 275 Sapiientia

282 Clorinde. Previously published periods and amplitudes are by Binzel and Mulholland (1983), 6.42 hours, 0.09 magnitudes; Behrend (2018web), 12.142 hours, 0.04 magnitudes; Bonamico and van Belle (2021), 49.352 hours, 0.26 magnitudes with a dense lightcurve obtained in an interval of more than three months 2020/11/26 to 2021/03/04 that looks convincing. New observations on 17 nights 2022/03/27 - 2022/05/20 provide a good fit to a somewhat irregular bimodal lightcurve with period 49.350 ± 0.003 hours, amplitude 0.19 ± 0.02 magnitudes (Fig. 6). This result is in excellent agreement with Bonamico and van Belle (2021). All of the earlier reported short periods are now ruled out.

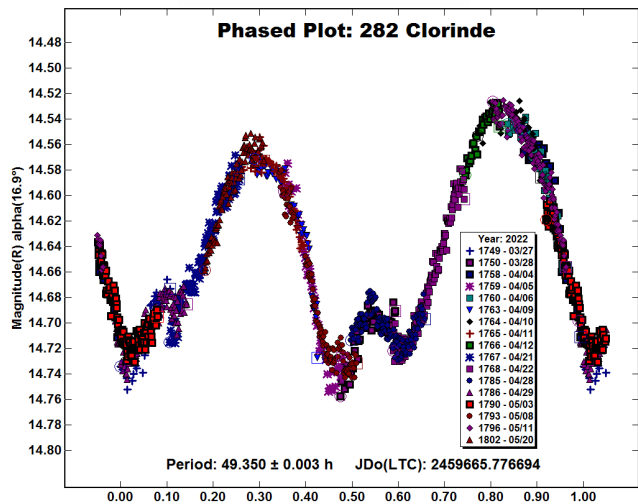


Figure 6. Lightcurve of 282 Clorinde phaased to 49.350 hours.

414 Liriope. Three early published results all assumed the usual two maxima and minima per rotational cycle: Alvarez (2012), 7.353 hours; Chang et al. (2015), 7.38 hours; and Waszczak et al. (2015), 7.34 hours. Three recent publications all reveal that there are three unsymmetrical maxima and minima per rotational cycle with 3/2 of the early and now rejected period: Colazo et al. (2020), 11.005 hours; Pál et al. (2020), 11.0065 hours; Dose (2021), 11.007 hours. New observations on 5 nights 2022/04/30 - 2022/05/09 provide a good fit to a lightcurve with period 11.009 ± 0.002 hours, amplitude 0.14 ± 0.01 magnitudes, and three unsymmetrical maxima and minima per rotational cycle (Fig. 7). The new result is in excellent agreement with Colazo et al. (2020), Pál et al. (2020), and Dose (2021).

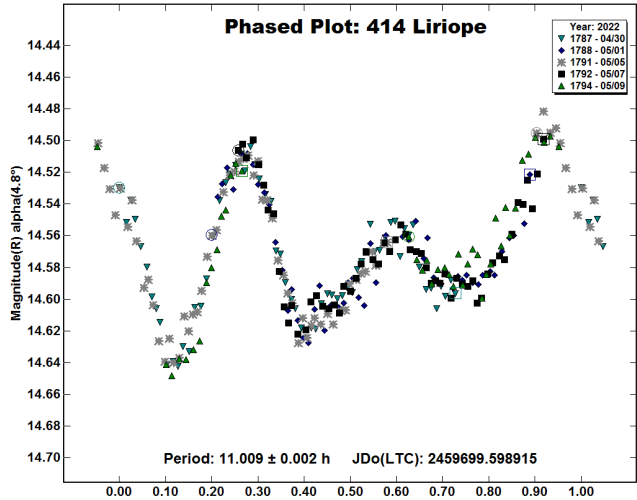


Figure 7. Lightcurve of 414 Liriope phased to 11.009 hours.

542 Susanna. Previously published periods are by Stephens (2007), 10.069 hours; Behrend (2016web), 10.0869 hours; and Pál et al. (2020), 10.107 hours. New observations on four nights 2022 June 3 - July 1, over an interval of 66 rotational cycles, provide a fit to an irregular lightcurve with three maxima and minima per rotational cycle, period 10.089 ± 0.001 magnitudes, amplitude 0.09 ± 0.01 magnitudes (Fig. 8). This value is consistent with all previously published periods.

Number	Name	2022/mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E	Amp	A.E.
233	Asterope	05/10-06/06	* 2.8, 9.0	235	2	19.694	0.001	0.41	0.02
240	Vanadis	05/10-06/01	* 2.4, 5.8	235	2	10.565	0.002	0.07	0.01
275	Sapiientia	04/08-05/18	* 8.2, 12.2	213	6	14.933	0.001	0.10	0.01
282	Clorinde	03/27-05/20	* 16.9, 9.5	223	12	49.350	0.003	0.19	0.02
414	Liriope	04/30-05/09	4.8, 6.8	209	11	11.009	0.002	0.14	0.02
542	Susanna	06/03-07/01	* 6.0, 10.3	256	14	10.089	0.001	0.09	0.01

Table I. Observing circumstances and results. The phase angle is given for the first and last date, with a * shown if a minimum value was reached between these dates. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984).

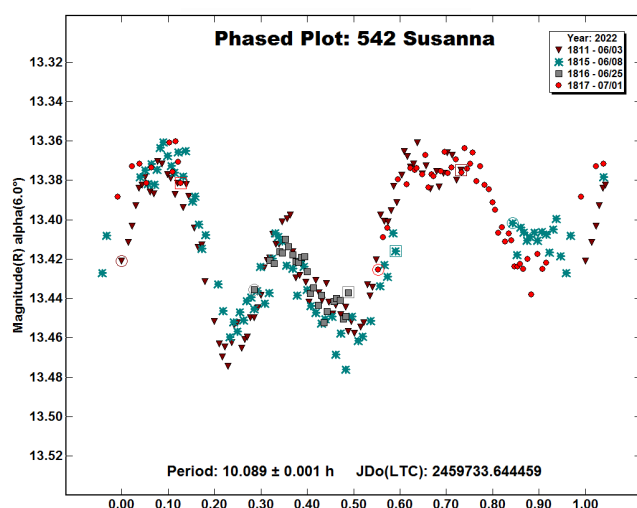


Figure 8. Lightcurve of 542 Susanna phased to 10.089 hours.

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