LIGHTCURVES AND ROTATION PERIODS OF 330 ADALBERTA, 494 VIRTUS, 530 TURANDOT, 784 PICKERINGIA, AND 1009 SIRENE

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Synodic rotation periods and amplitudes are found for 330 Adalberta: 3.5553 ± 0.0001 h, 0.43 ± 0.02 mag; 494 Virtus: 40.42 ± 0.01 h, 0.21 ± 0.01 mag; 530 Turandot: 19.961 ± 0.001 h, 0.10 ± 0.01 mag; 784 Pickeringia: 13.169 ± 0.001 h, 0.19 ± 0.01 mag, and 1009 Sirene: 2.8796 ± 0.0005 h, 0.09 ± 0.02 mag. For 494 Virtus, V-R = 0.36; H(V) = 9.118 ± 0.023, G = 0.151 ± 0.039.

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, unguided, clear filter. 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. 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.

330 Adalberta. The only previously published rotation data set is by Alvarez and Pilcher (2014), 3.5553 h, 0.44 mag near celestial longitude 338°. New observations on four nights 2021 Oct. 11 - Nov. 8, near celestial longitude 37°, provide an excellent fit to exactly the same period, 3.5553 ± 0.0001 h, and an almost identical amplitude of 0.43 ± 0.02 mag.

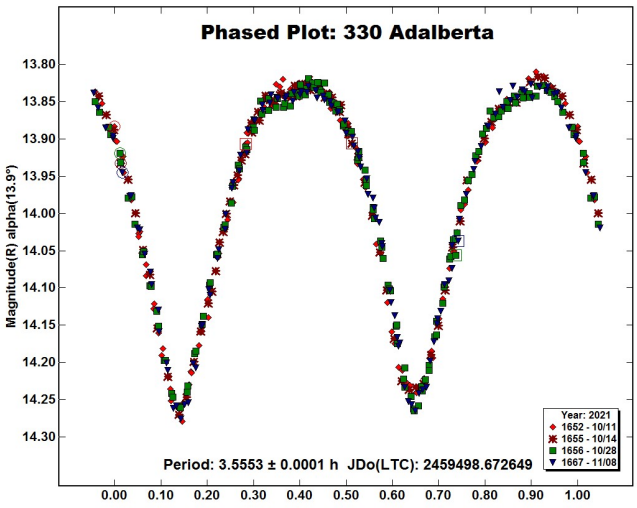

Figure 1. The lightcurve of 330 Adalberta phased to a period of 3.5553 hours.

494 Virtus. Several previously published periods are in great discordance: Behrend (2006web), 4.99 h, 0.03 mag; Warner (2006), 5.57 h, 0.12 mag near celestial longitude 16°; Behrend (2008web), 4.9903 h, 0.03 mag; Hamanowa and Hamanowa (2009), 5.57 h, 0.03 mag near celestial longitude 167°; Polakis (2018), 49.427 h, 0.05 mag near celestial longitude 139°. New observations on 15 nights 2021 Oct. 9 - Nov. 30 near celestial longitude 52° provide a good fit to a somewhat irregular bimodal lightcurve with period 40.42 ± 0.01 hours, amplitude 0.21 ± 0.01 magnitudes. This new result based on a dense data set that covers the entire double period rules out all previously published periods.

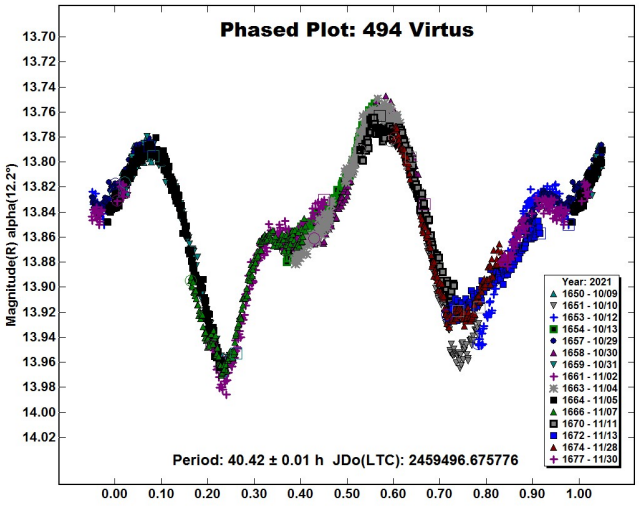

Figure 2. The lightcurve of 494 Virtus phased to a period of 40.42 hours.

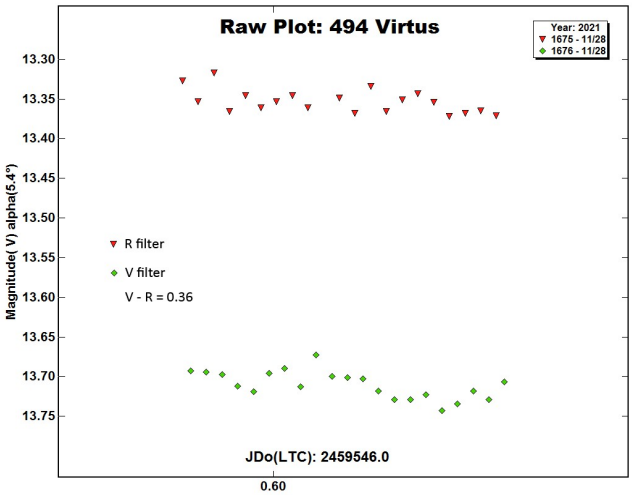

Figure 3. V and R lightcurves of 494 Virtus.

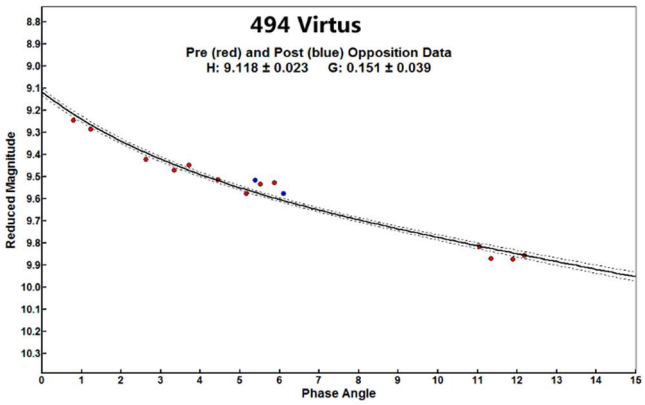

Figure 4. H-G plot for 494 Virtus in the V magnitude band.

On 2021 Nov. 28 twenty exposures were obtained alternating between the R and V filters. A raw lightcurve of both sessions

shows that V-R = 0.36. An H-G plot from phase angle –12.2° to –0.8° to +6.2° in the V magnitude band shows $H = 9.118 \pm 0.023$ and $G = 0.151 \pm 0.039$ at mid light.

530 Turandot. The Lightcurve Data Base (LCDB; Warner et al. 2009, updated 2021 December) lists five previously published rotation periods, four of which are within 0.02 hours of the adopted value of 19.96 hours. New observations on seven nights 2021 Nov. 1 - 29 provide an excellent fit to a period of 19.961 ± 0.001 hours with an amplitude 0.10 ± 0.01 magnitudes. This value is in very good agreement with most previously published values.

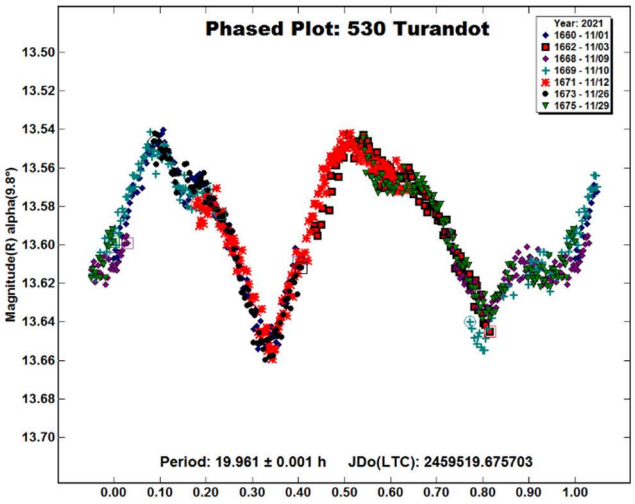

Figure 5. The lightcurve of 530 Turandot phased to a period of 19.961 hours.

784 Pickeringia. The Lightcurve Data Base (Warner et al. 2009, updated 2021 December) lists four previously published rotation periods that are all within 0.15 hours of the adopted value of 13.144 hours. New observations on four nights 2021 Nov. 6 - Dec. 6 provide an excellent fit to a period of 13.169 ± 0.001 hours, amplitude 0.19 ± 0.01 magnitudes. This value of the rotation period is consistent with other published values.

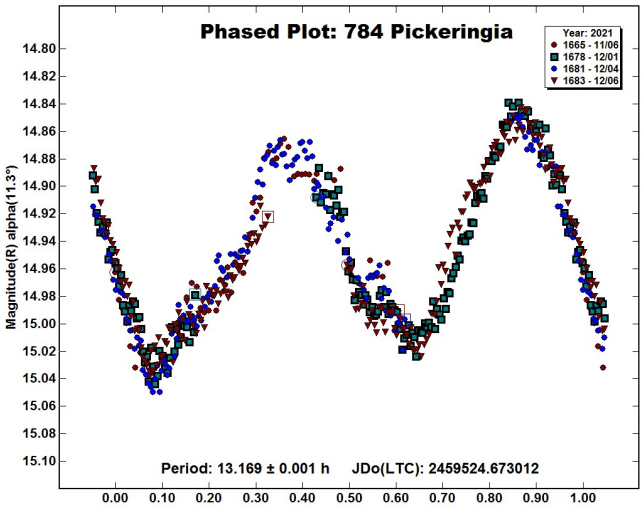

Figure 6. The lightcurve of 784 Pickeringia phased to a period of 13.169 hours.

1009 Sirene. This object has a highly eccentric and inclined orbit, $a = 2.629$, $e = 0.454$, $i = 15.73°$, H=13.9. In 2021 December it was just past perihelion and brighter than at any time in the previous several decades. Its faintness over this interval is the reason there are no previously published lightcurves.

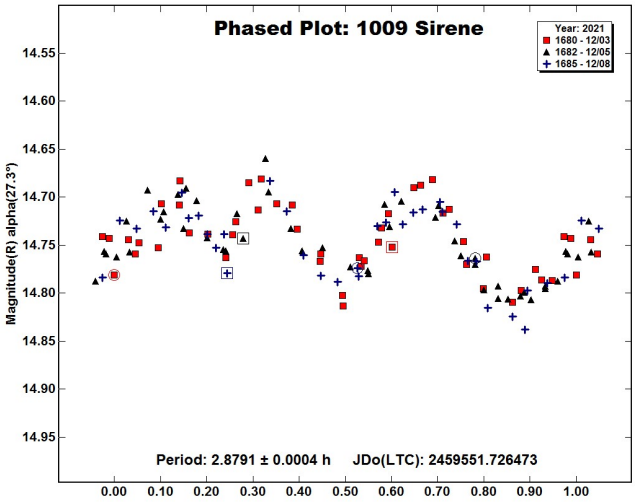

Figure 7. The lightcurve of 1009 Sirene, 2021 Dec. 3 - 8, phased to a period of 2.8791 hours

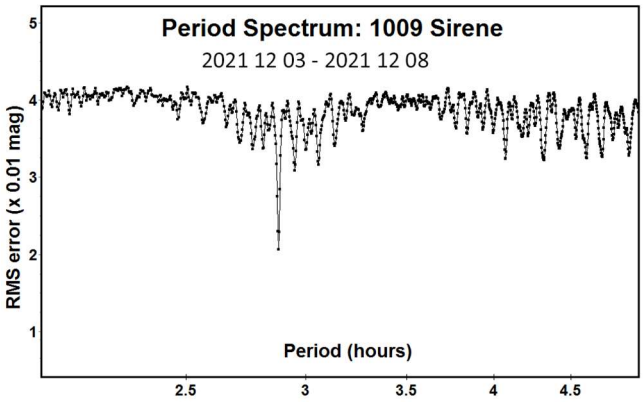

Figure 8. The period spectrum of 1009 Sirene, 2021 Dec. 3 - 8, between 2 and 5 hours.

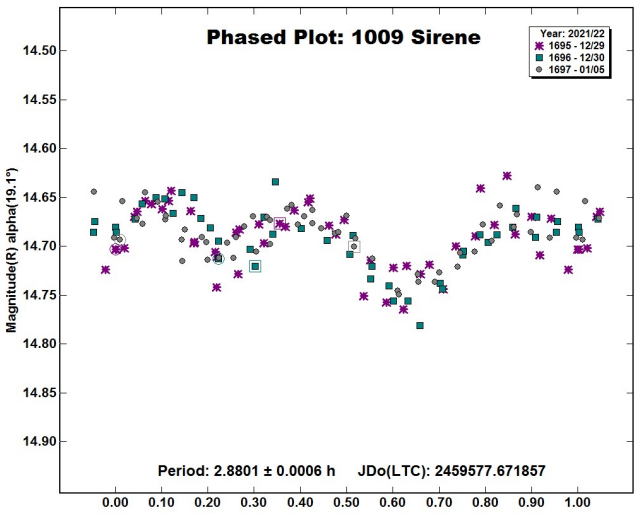

Figure 9. The lightcurve of 1009 Sirene, 2021 Dec. 29 - 2022 Jan. 5, phased to a period of 2.8801 hours.

Number	Name	20yy/mm/dd	Phase	L_{PAB}	L_{PAB}	Period(h)	P.E	Amp	A.E.
330	Adalberta	21/10/11-21/11/08	*13.9,9.2	37	-9	3.5553	0.0001	0.43	0.02
494	Virtus	21/10/09-21/11/30	*12.2,6.2	52	2	40.42	0.01	0.21	0.01
530	Turandot	21/11/01-21/11/29	*9.8,3.8	64	-10	19.961	0.001	0.10	0.01
784	Pickeringia	21/11/06-21/12/06	11.2,5.0	86	13	13.169	0.001	0.19	0.01
1009	Sirene	21/12/03-21/12/08	27.3,25.3	98	-17	2.8791	0.0004	0.09	0.02
1009	Sirene	21/12/30-22/01/05	19.1,18.6	104	-22	2.8801	0.0006	0.08	0.02

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

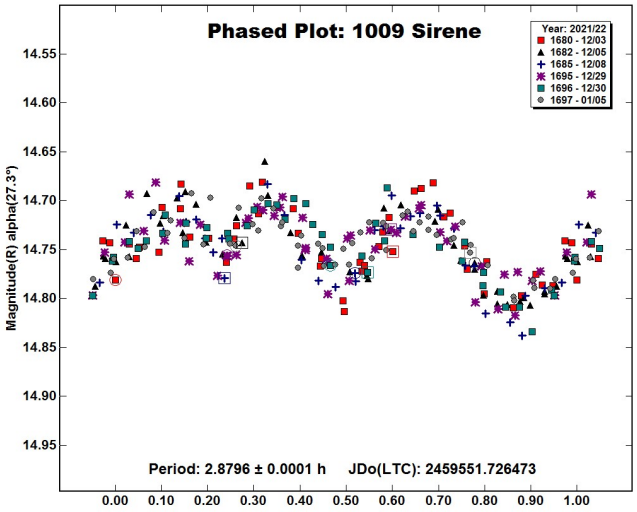

Figure 10. The lightcurve of 1009 Sirene, 2021 Dec. 3 - 2022 Jan. 5, phased to a period of 2.8796 hours.

More than 20 hours of photometric monitoring on three nights form 2021 Dec. 3-8 near celestial longitude 98°, celestial latitude -17°, and phase angle 26° provide a good fit to an asymmetric trimodal lightcurve with period 2.8791 ± 0.0004 hours, amplitude 0.09 ± 0.02 magnitudes. The period spectrum from 2 to 5 hours is presented. It shows one narrow minimum at 2.8791 hours much deeper than any other minima, strong evidence that between 2 hours and 5 hours no rotation period other than 2.8791 hours can be supported by these data. The split halves plot of the double period 5.758 hours (not presented here but available from the author on request) shows that the tenth order Fourier curves of the two halves are much closer together than the scatter of the individual data points, strong evidence against the double period. I offer two reasons to rule out one or two maxima and minima per cycle. Either would require a period less than the 2.2 hours centrifugal limit. Simple eyeballing of the lightcurve, and seeing the asymmetry of the three maxima, would also rule out a shorter period with fewer maxima and minima per rotational cycle, even if the centrifugal limit did not apply. All of these combined circumstances show that any period except 2.8791 hours can be ruled out. Hence, I claim that a period of 2.8791 hours is the correct one.

Mars-crossers do not move as rapidly across the sky as Earth crossers, but move faster than ordinary main belt asteroids. Three more sessions were obtained 2021 Dec. 29 - 2022 Jan. 5 near celestial longitude 104°, celestial latitude -22°, phase angle 19°. The lightcurve of these three sessions is somewhat noisier than the 2021 Dec. 3-8 lightcurve, but shows only a slightly different period, 2.8801 ± 0.0006 hours, and amplitude, 0.08 ± 0.02 magnitudes. The synodic periods for these two intervals differ by an amount no greater than their formal errors. The difference may not be significant. It may be useful to plot a phased lightcurve of all six sessions, which shows a mean synodic period for the interval 2021 Dec. 3 - 2022 Jan. 5 of 2.8796 hours. The real error is likely to be larger than the formal error of 0.0001 hours and I present the result as 2.8796 ± 0.0005 hours.

References

Alvarez, E.M.; Pilcher, F. (2014). "Period determination for 330 Adalberta: a low numbered asteroid with a previously unknown period." *Minor Planet Bull.* **41**, 23-24.

Behrend, R. (2006web, -2008web). Observatoire de Geneve web site. *http://obswww.unige.ch/~behrend/page_cou.html*

Hamanowa, H.; Hamanowa, H. (2009). "Lightcurves of 494 Virtus, 556 Phyllis, 657 Gunlod, 1111 Reinmuthia, 1188 Gothlandia, and 1376 Michelle." *Minor Planet Bull.* **36**, 87-88.

Harris, A.W.; Young, J.W.; Scaltriti, F.; Zappala, V. (1984). "Lightcurves and phase relations of the asteroids 82 Alkmene and 444 Gyptis." *Icarus* **57**, 251-258.

Polakis, T. (2018). "Lightcurve analysis for eleven main-belt minor planets." *Minor Planet Bull.* **45**, 269-273.

Warner, B.D. (2006). "Asteroid lightcurve analysis at the Palmer Divide Observatory - late 2005 and early 2006." *Minor Planet Bull.* **33**, 58-62.

Warner, B.D.; Harris, A.W.; Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146. Updated 2021 Dec. *https://www.minorplanet.info/php/lcdb.php*