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LIGHTCURVES AND ROTATION PERIODS OF 67 ASIA, 74 GALATEA, 356 LIGURIA, 570 KYTHERA, 581 TAUNTONIA, 589 CROATIA, AND 605 JUVISIA

Frederick Pilcher
Organ Mesa Observatory (G50)
4438 Organ Mesa Loop
Las Cruces, NM 88011 USA
fpilcher35@gmail.com

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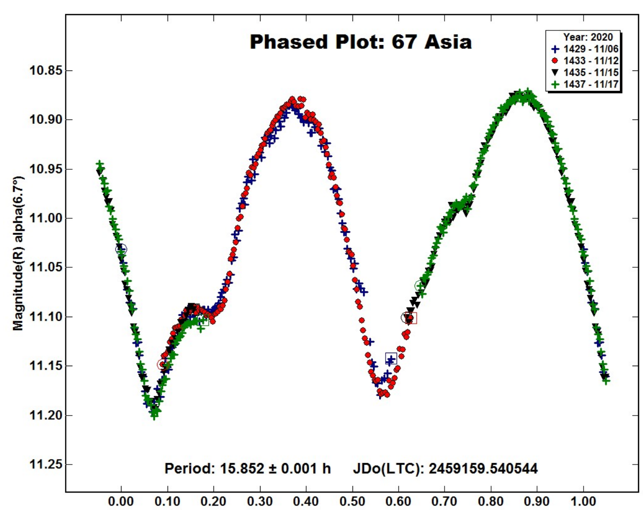
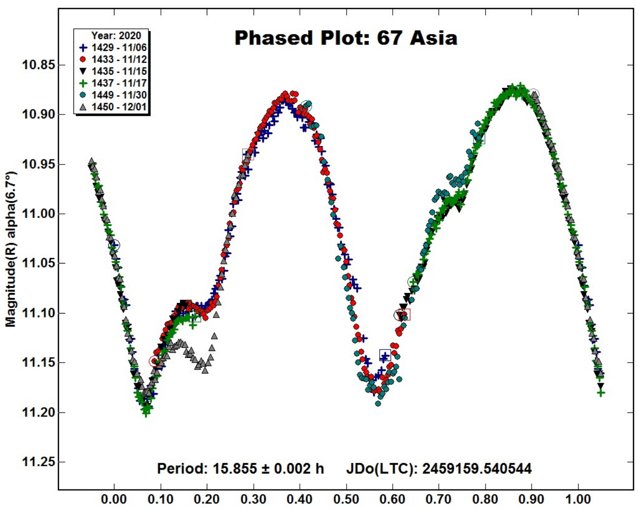
Synodic rotation periods and amplitudes are found for 67 Asia: 15.855 ± 0.002 h, 0.32 ± 0.02 mag; 74 Galatea: 17.266 ± 0.001 h, 0.06 ± 0.01 mag; 356 Liguria: 31.690 ± 0.002 h, 0.14 ± 0.01 mag; 570 Kythera: 8.117 ± 0.001 h, 0.09 ± 0.01 mag; 581 Tauntonia: 24.994 ± 0.002 h, 0.10 ± 0.01 mag; 589 Croatia: 24.932 ± 0.001 h, 0.25 ± 0.01 mag; 605 Juvisia: 15.844 ± 0.001 h, 0.18 ± 0.01 mag.

Observations to obtain the data used in this paper were made at the Organ Mesa Observatory with a 0.35-m Meade LX200 GPS Schmidt-Cassegrain (SCT) and SBIG STL-1001E CCD. Exposures were 60 seconds, unguided, with a clear filter except where otherwise noted. Photometric measurement and lightcurve construction are with *MPO Canopus* software. 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. For each target a split halves plot of the double period has been plotted that shows the two halves of the double period are very nearly the same. Therefore, the double period may be ruled out for each target. Although not shown in this paper, these plots are available from the author on request.

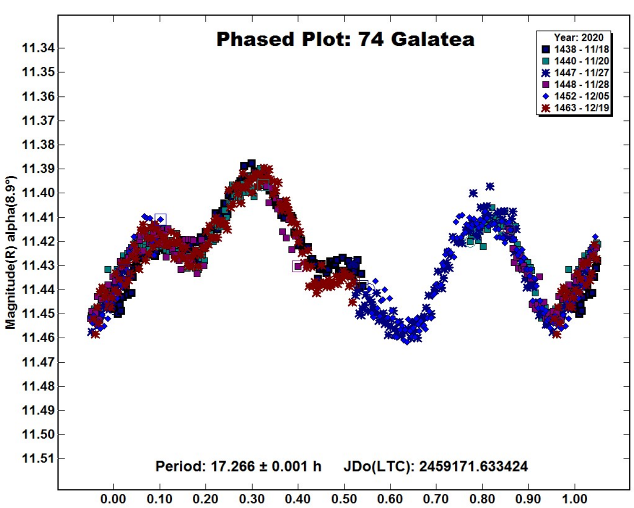
67 Asia. The Asteroid Lightcurve Database (Warner et al, 2009) states a secure period of 15.853 hours based on six independent period determinations all within 0.05 hours of the preferred value. A lightcurve based on new observations on four nights 2020 Nov. 6-17 at phase angles from 6.7º to 11.8º provide an excellent fit to a period 15.852 ± 0.001 h, amplitude 0.32 ± 0.02 mag. These four sessions were timed to obtain full phase coverage of the double period, whose split halves plot, not presented, shows a near perfect overlap of the two halves. The double period may be safely ruled out.



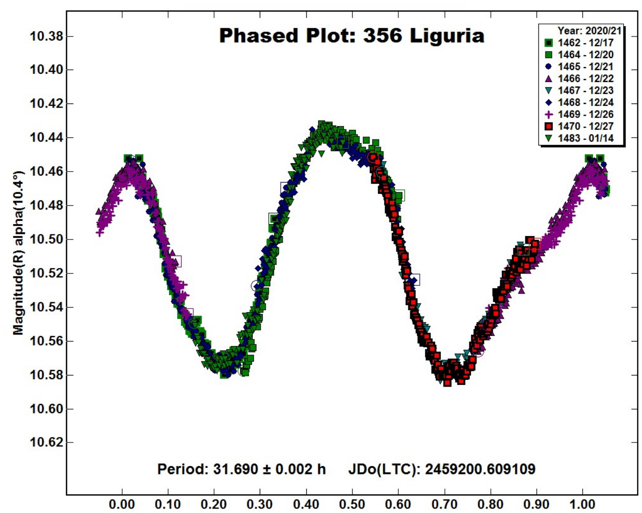
Two additional sessions were obtained 2020 Nov. 30 and Dec. 1 near phase angle 17º as a full moon target. In the phased lightcurve representing all six sessions, the small hump near phase 0.75 had increased slightly on Nov. 30, and the small depression near phase 0.2 was much deeper on Dec. 1 than on Nov. 6-17. Such changes of lightcurve shape with increasing phase angle are commonly found for many asteroids. The lightcurve based on six sessions 2020 Nov. 6 - Dec. 1 has period 15.855 ± 0.002 h, amplitude 0.32 ± 0.02 mag. This result is consistent with all previously published results.



74 Galatea. There are five previously published rotation periods, with periods, amplitudes, and celestial longitudes as stated. Harris and Young (1980), 9.0 h, 0.14 mag, 24º; Behrend (2001), 8.629 h, 0.09 mag, 346º; and Behrend (2013), 8.643 h, 0.13 mag, 179º all published lightcurves with the usual two maxima and minima per rotational cycle. Pilcher (2008), 17.270 h, 0.08 mag, 157º; Pilcher (2009), 17.268 h, 0.16 mag, 216º on both occasions found four unsymmetric maxima and minima per rotation cycle that ruled out a period near 8.6 hours. New observations on six nights 2020 Nov. 18 - Dec. 19 provide a good fit to an unsymmetric lightcurve with period 17.266 ± 0.001h, amplitude 0.06 ± 0.01 mag at celestial longitude 73º. The new result is in excellent agreement with Pilcher (2008) and (2009). Even a cursory examination of the new lightcurve shows again that a period near 8.6 hours is definitively ruled out.



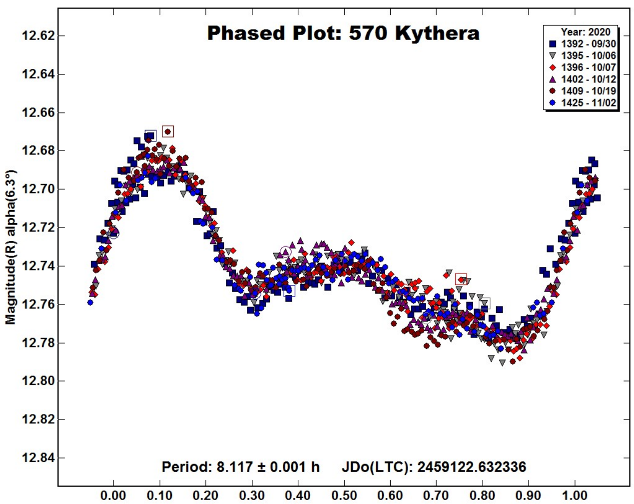
356 Liguria. There have been only two previously published rotation periods for this bright asteroid. Harris and Young (1980), 31.82 hours; and a much more comprehensive campaign 2017 Feb. 22 - May 3 by this author (Pilcher, 2017) that found an ambiguous result. Depending upon the interpretation of the lightcurves, the period might be either 31.701 hours with the usual two maxima and minima per rotational cycle, or twice that amount (63.395 hours) with four maxima and minima per cycle. The two halves of a split halves plot for the longer period did not have a perfect overlap. The observations were not uniformly distributed in time or among the large range of phase angles encountered in the interval. Observations at different phase angles were represented by the two halves of the split halves plot. The period might be 31.701 hours with two maxima and minima per cycle and the lightcurve shape changing with phase angle as is commonly found for many asteroids. Or the period might be 63.395 hours with four unsymmetric maxima and minima per cycle.



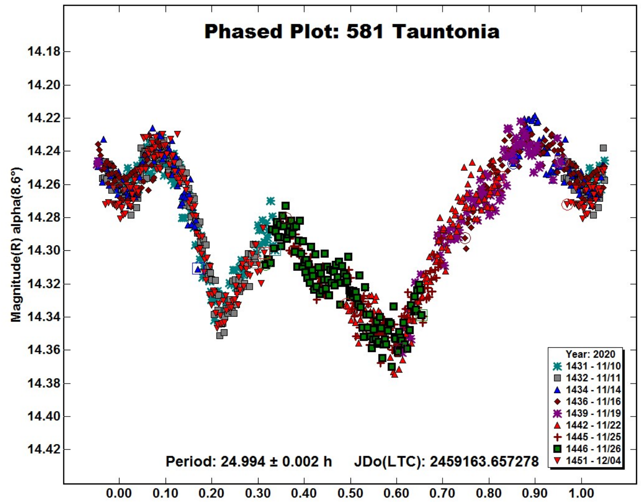
In 2020 December 356 Liguria came to opposition at declination +37º and with the longest nights of the year near winter solstice. Eight single night sessions, each of 10 to 11 hours, 2020 Dec. 17-27 provided complete phase coverage of the longer period with generous 2 to 3 hour overlap between adjacent segments. The R filter was used for this bright target. An excellent fit of all eight sessions was obtained for a lightcurve phased to 31.682 ± 0.004 h, amplitude 0.14 ± 0.01 mag. The split halves lightcurve phased to 63.367 hours shows near perfect overlap between the two halves. The longer period can now be ruled out, and the shorter period supported by data 2020 Dec. 17-27 is secure. Covering fewer than eight rotational cycles of the target, it is, however, not highly accurate.

To improve the accuracy of the period, another session was obtained 2021 Jan. 14, with 21 rotational cycles between the first and last sessions. The accompanying lightcurve aligns the minima of 2020 Dec. 17 and 2021 Jan. 14 with excellent fit to a period 31.690 ± 0.002 h, amplitude 0.14 ± 0.01 mag. This period agrees within 0.03% of the period found in 2017 (Pilcher, 2017).

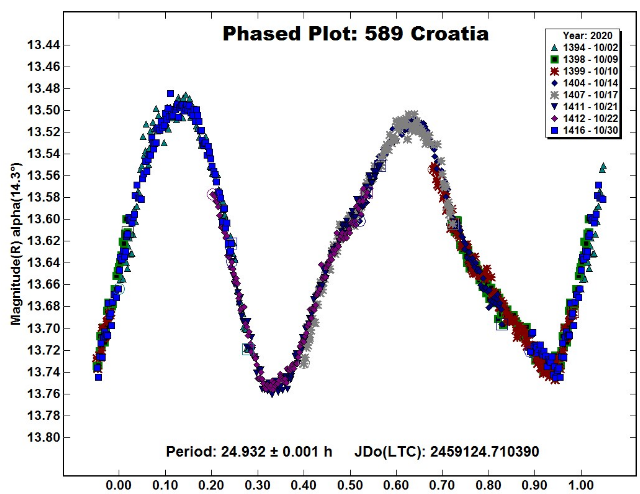
570 Kythera. Many different rotation periods have been published: Blanco et al., (2000), 6.919 h; Lagerkvist et al. (2001), 5.682 h; Gil-Hutton and Cañada (2003), 6.903 h; Behrend (2004), 8.120 h; Chavez (2014), 10.5h; Aznar Macias et al. (2016), 8.074 h. New observations on six nights 2020 Sept. 30 - Nov. 2 provide a good fit to an irregular lightcurve with period 8.117 ± 0.001 h, amplitude 0.09 ± 0.01 mag. A split halves plot of the double period shows that the two halves are almost identical, and rules out the double period. This result is consistent with Behrend (2004) and Aznar Macias et al. (2016), and rules out all other reported periods.



581 Tauntonia. Previously reported rotation periods are by Behrend (2005), 16.54 h; Behrend (2006), 16.19 h; Stephens (2010), 24.90 h; Marciniak et al. (2018), 24.987 h. New observations on 9 nights 2020 Nov 10 - Dec. 4 provide a good fit to an irregular lightcurve with period 24.994 ± 0.002 h, amplitude 0.10 ± 0.01 mag. The nights of observation were selected so that the entire double period was also covered. The split halves plot of the double period, not presented, shows a near perfect overlap of the two halves. A period of 24.994 hours may now be considered secure. This value is very close to Stephens (2010) and Marciniak et al. (2018). The two periods reported by Behrend are now ruled out.



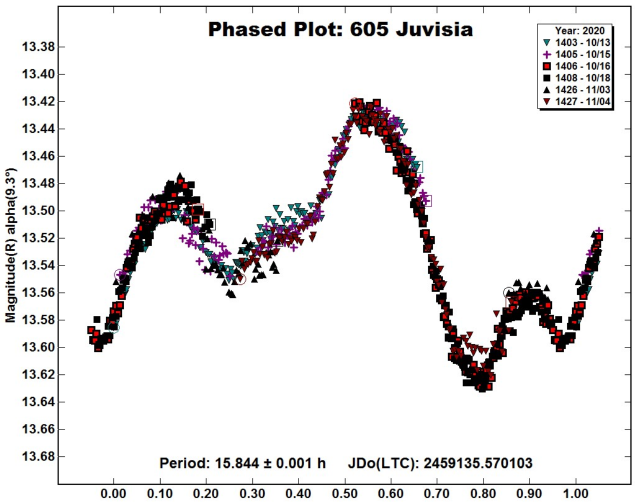
589 Croatia. Several different rotation periods have been published previously: Warner (2008), 11.7 h; Behrend (2013), 24.831 h; Waszczak et al. (2015), 16.385 h; Mas et al. (2018), 24.734 h. New observations on 8 nights 2020 Oct. 2 - 30 provide an excellent fit to a lightcurve with period 24.932 ± 0.001 h, amplitude 0.25 ± 0.01 mag. By selecting an odd number of days between sessions the entire double period was also covered. The split halves plot of the double period, not presented, shows a near perfect overlap of the two halves. A period of 24.932 hours may now be considered secure. This value is close to Behrend (2013) and to Mas et al. (2018) and rules out all other reported periods.



Number	Name	yyyy/mm/dd	Phase	LPAB	BPAB	Period(h)	P.E	Amp	A.E.
67	Asia	2020/11/06-2020/12/01	6.7, 17.0	32	-2	15.855	0.002	0.32	0.02
74	Galatea	2020/11/18-2020/12/19	*8.9, 7.5	73	-4	17.266	0.001	0.06	0.01
356	Liguria	2020/12/17-2021/01/14	*10.4, 9.7	100	11	31.690	0.002	0.14	0.01
570	Kythera	2020/09/30-2020/11/02	*6.3, 6.3	23	1	8.117	0.001	0.09	0.01
581	Tauntonia	2020/11/10-2020/12/04	*8.6, 6.1	65	-17	24.994	0.002	0.10	0.01
589	Croatia	2020/10/02-2020/10/30	14.3 6.4	50	-10	24.932	0.001	0.25	0.01
605	Juvisia	2020/10/13-2020/11/04	*9.3 10.0	30	19	15.844	0.001	0.18	0.01

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date, with an asterisk if a minimum was reached between the first and last dates. LPAB and BPAB are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984).

605 Juvisia. Warner (2000) based on data obtained in year 1999, published a period of 15.855 h. Later Warner (2011) reexamined the year 1999 data and obtained a period of 15.93 h. Menke (2005) in a separate investigation published a period of 15.85 h. New observations on six nights 2020 Oct. 13 - Nov. 4 provide a good fit to a period 15.844 ± 0.001 h, amplitude 0.18 ± 0.01 mag. This period is in good agreement with previously reported periods, and the near perfect overlap of the two halves of the split halves plot also rules out the double period.



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