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LIGHTCURVES AND ROTATION PERIODS OF 102 MIRIAM, 126 VELLEDA, 294 FELICIA, 547 PRAXEDIS, 716 BERKELEY, 1166 SAKUNTALA, AND 2535 HAMEENLINNA

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Synodic rotation periods and lightcurve amplitudes at their year 2023 oppositions are found for 102 Miriam 23.618 ± 0.002 hours, 0.11 ± 0.01 magnitudes; 126 Velleda 5.3674 ± 0.0001 hours, 0.20 ± 0.01 magnitudes; 294 Felicia 10.426 ± 0.001 hours, 0.15 ± 0.01 magnitudes; 547 Praxedis 9.104 ± 0.002 hours, 0.06 ± 0.02 magnitudes; 716 Berkeley 15.580 ± 0.001 hours, 0.16 ± 0.02 magnitudes; 1166 Sakuntala 6.2912 ± 0.0002 hours, 0.21 ± 0.01 magnitudes; 2535 Hameenlinna 3.2312 ± 0.0002 hours, 0.10 ± 0.02 magnitudes. For 102 Miriam, V-R = 0.36, H = 9.32, G = 0.21. For 126 Velleda, V-R = 0.49, H = 9.40, G = 0.21.

The new 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 to 120 second exposures, unguided, clear filter. Image measurement and lightcurve construction were with *MPO Canopus* software with calibration star magnitudes for solar colored stars from the CMC15 catalog reduced to the Cousins R band. Zero-point adjustments of a few × 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.

102 Miriam. All early observations were made at oppositions near perihelion at longitude 358° and assumed the usual two maxima and minima per rotational cycle. These include Shevchenko et al. (1997), 15.789h; Riccioli et al. (2001), 15.853h; Johnson et al. (2008), 15.789 h; and a recent result by Behrend (2020web), 15.79h. This author (Pilcher, 2008), with observations extending for a much longer interval of two months near celestial longitude 21°, found a period of 23.613h with three unequal maxima and minima per rotational cycle that ruled out all periods near 15.8h. At a different celestial longitude of 117°, this author (Pilcher, 2013), again based on two months of observations, found a good fit to a period of 23.625h with a lightcurve including two unevenly spaced maxima and minima and smaller scale irregularities, again definitively ruling out a period approximately 2/3 as great. Franco et al. (2021) near celestial longitude 24° published a period of 23.63 hours. New observations on seven nights 2023 Mar. 27 - May 23 near celestial longitude 202° also provide a good fit to a lightcurve (Figure 1) with two asymmetric maxima, additional irregularities, a period of 23.618 ± 0.002 hours, and amplitude 0.11 ± 0.01 magnitudes. This period is compatible with the dense lightcurves of Pilcher (2008), Pilcher (2013), and Franco et al. (2021).

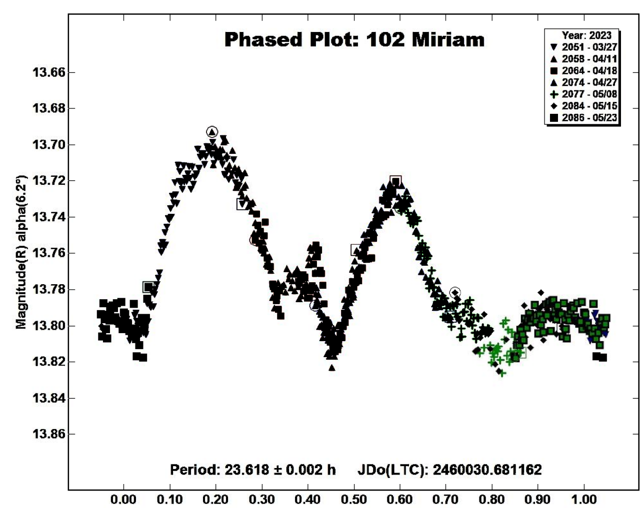

Figure 1. Phased lightcurve of 102 Miriam.

On 2023 Apr. 18, twenty images were obtained alternately with the R and V filters. Both image sets were measured with the same calibration stars. The method of extracting their R and V colors is explained by this author in Pilcher et al. (2016). The composite lightcurve (Figure 2) shows that V-R = 0.36. The calibrated R magnitudes found for each session were converted to V magnitudes by adding 0.36. An H-G plot in the V band (Figure 3) shows that at mid-light H = 9.323 ± 0.026, G = 0.212 ± 0.042.

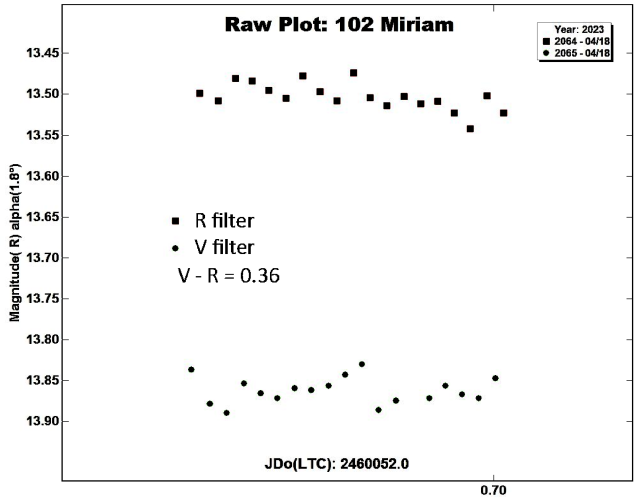

Figure 2. Raw lightcurve of 102 Miriam with V and R filters.

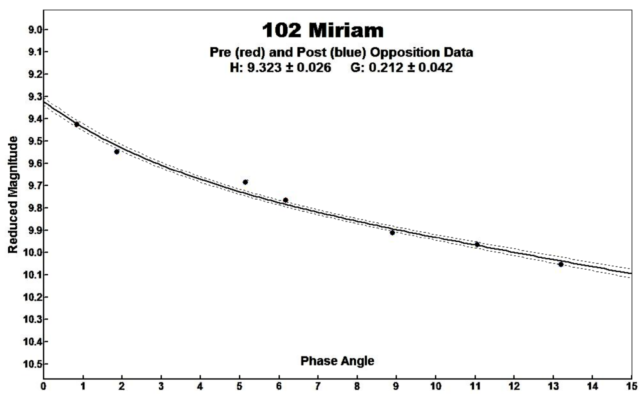

Figure 3. H-G plot for 102 Miriam.

126 Velleda. The Lightcurve Database (Warner et al., 2009) lists seven previously published rotation periods of 126 Velleda, all of them close to the adopted value of 5.3672 hours. New observations were made on eight nights 2023 Mar. 28 at phase angle -6.0° to Apr. 10 at phase angle 0.2° to May 13 at phase angle 13.8°. They provide an excellent fit to an irregular lightcurve (Figure 4) with period 5.3674 ± 0.0001 hours, amplitude 0.20 ± 0.01 magnitudes. This value is in very close agreement with previously published values. On 2023 Apr. 22 twenty images were taken alternately with R and V filters. Using the same method described in Pilcher (2016) as for 102 Miriam, the composite lightcurve with both filters shows V-R = 0.49 (Figure 5). An H-G plot in the V band (Figure 6) shows that at mid-light H = 9.399 ± 0.041, G = 0.208 ± 0.071.

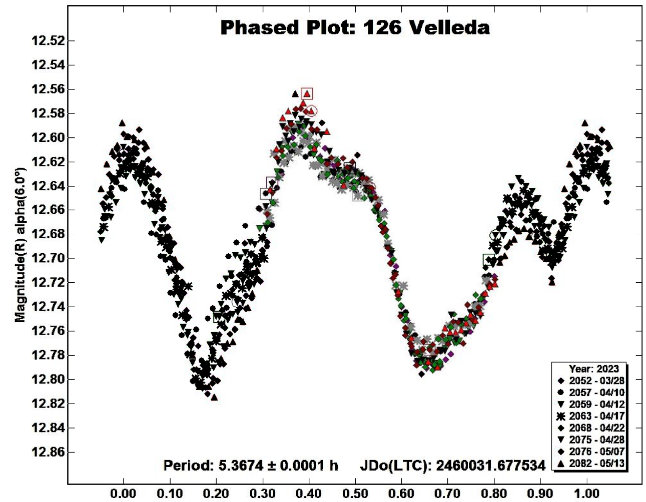

Figure 4. Phased lightcurve of 126 Velleda.

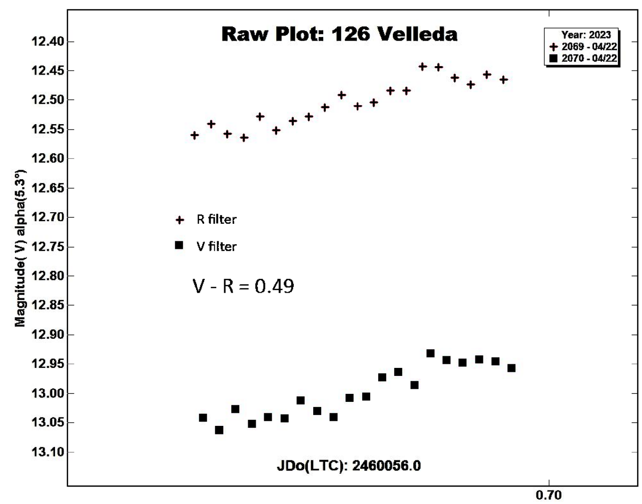

Figure 5. Raw lightcurve of 126 Velleda with V and R filters.

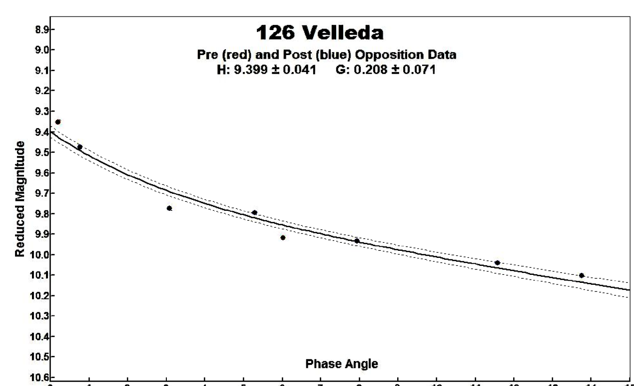

Figure 6. H-G plot for 126 Velleda.

294 Felicia. The Lightcurve Database (Warner et al., 2009) lists three previously published rotation periods of 294 Felicia, all of them near longitude 315° at the opposition of 2007 August and very close to the adopted value of 10.4227 hours. New observations on five nights 2023 Apr. 20 - May 10 near longitude 223° provide a good fit to a somewhat asymmetric bimodal lightcurve (Figure 7) with period 10.426 ± 0.002 hours, and amplitude 0.15 ± 0.01 magnitudes. This period is in excellent agreement with the rotation periods found in the year 2007.

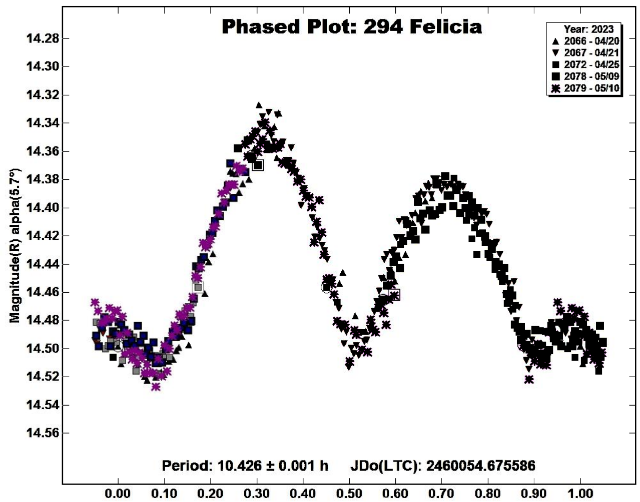

Figure 7. Phased lightcurve of 294 Felicia.

547 Praxedis. Previously published rotation periods are by Cooney and Robinson (2002), 9.105 h; Higgins et al. (2008), 9.106 h; and Behrend, (2019web), 9.1035 h., all with amplitudes between 0.04 and 0.12 magnitudes and irregular lightcurves. New observations on six nights 2023 June 11 - July 7 fit a lightcurve with period 9.104 ± 0.002 hours (Figure 8). The lightcurve has a single maximum and minimum, as often occurs when an asteroid is observed at an aspect not far from the rotational pole. The amplitude increased from 0.04 magnitudes in early June at phase angle near 8° to 0.08 magnitudes July 7 at phase angle 12.6°. The rotation period found in this investigation is in very close agreement with all other published rotation periods.

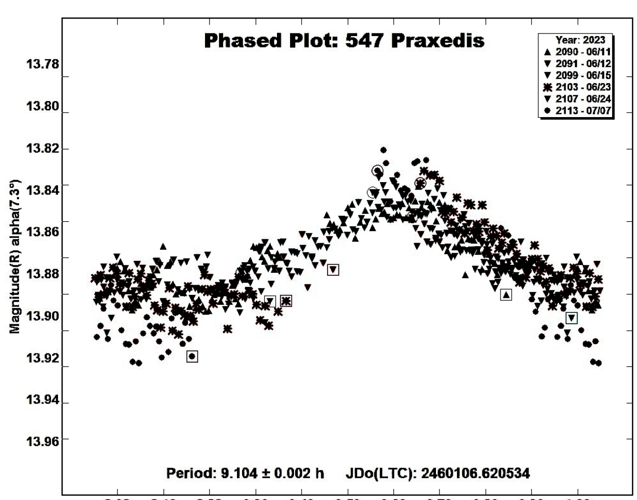

Figure 8. Phased lightcurve of 547 Praxedis.

716 Berkeley. Previously published rotation periods are by Lagerkvist (1978), >17h; Garlitz (2011), 15.55h; Behrend (2018web), 34.3h; and Polakis (2021), 15.46h. New sessions on seven nights 2023 Mar. 24 - Apr. 26 provide a good fit to a period 15.580 ± 0.001 hours, amplitude 0.16 ± 0.02 magnitudes, with an unsymmetrical bimodal lightcurve (Figure 9). This value is consistent with Garlitz (2011) and Polakis (2021), and rules out the results by Lagerkvist (1978) and Behrend (2018web).

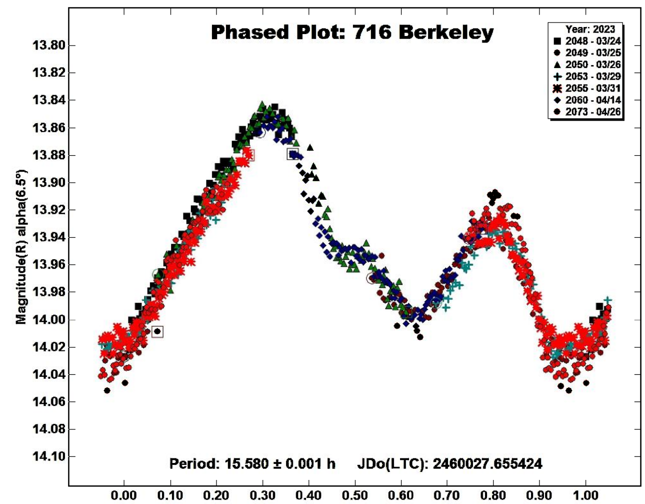

Figure 9. Phased lightcurve of 716 Berkeley.

1166 Sakuntala. Previously published periods are by Malcolm (2001), 6.3 h; Behrend (2002web), >20 h; Behrend (2003web), >20h; Behrend (2005web), >20h; Brincat, (2016), 6.2915 h; Garcerán et al. (2016), 6.29h; Franco et al. (2019), 6.2918 h; Franco et al. (2022), 6.291h. New observations on four nights 2023 June 13 - 25 provide a good fit to a lightcurve (Figure 10) with period 6.2912 ± 0.0002 hours, amplitude 0.21 ± 0.01 magnitudes. This value is in excellent agreement with Malcolm (2001), Brincat (2016), Garcerán et al. (2016), Franco et al. (2019) and Franco et al. (2022), and rules out all three values published by Behrend.

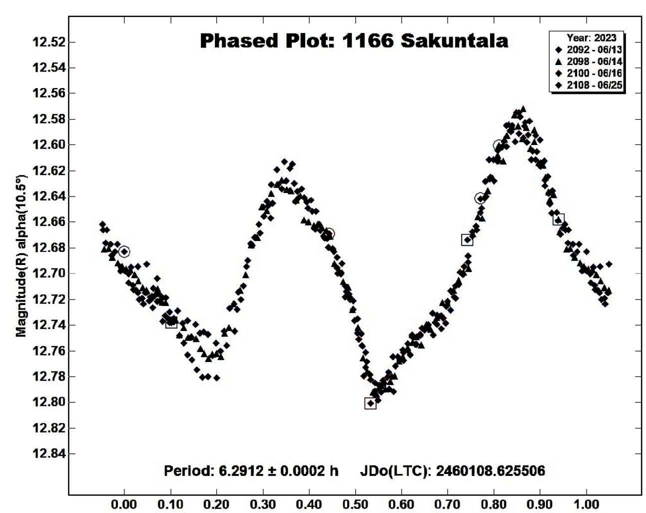

Figure 10. Phased lightcurve of 1166 Sakuntala.

Number	Name	yyyy/mm/dd	Phase	LPAB	BPAB	Period(h)	P.E	Amp	A.E.
102	Miriam	2023/03/27-2023/05/23	* 6.2 - 13.2	202	-1	23.618	0.002	0.11	0.01
126	Velleda	2023/03/28-2023/05/13	* 6.0 - 13.8	200	0	5.3674	0.0001	0.20	0.01
294	Felicia	2023/04/20-2023/05/10	* 5.7 - 3.9	223	8	10.426	0.001	0.15	0.01
547	Praxedis	2023/06/11-2023/07/07	7.3 - 12.6	255	19	9.104	0.002	0.06	0.02
716	Berkeley	2023/03/24-2023/04/26	* 6.5 - 10.4	194	8	15.580	0.001	0.16	0.02
1166	Sakuntala	2023/06/13-2023/06/25	10.5 - 14.1	235	13	6.2912	0.0002	0.21	0.01
2535	Hameenlinna	2023/03/30-2023/04/19	3.7 - 7.8	195	2	3.2312	0.0002	0.10	0.02

Table I. Observing circumstances and results. The phase angle is given for the first and last date, unless a minimum (second value) was reached. LPAB and BPAB are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984).

2535 Hameenlinna. Previously published rotation periods are by Benishek et al. (2016), 3.23106 h; Sada et al. (2017), 3.2311 h; Behrend (2018web), 3.2288 h; Pravec et al. (2018web), 3.2312 h; and Pál et al. (2020), 3.2305 h. New sessions on four nights 2023 Mar. 30 - Apr. 19 provide a good fit to a lightcurve (Figure 11) with period 3.2312 ± 0.0002 hours, amplitude 0.10 ± 0.02 magnitudes, and a slightly asymmetric bimodal lightcurve. The period spectrum (Figure 12) is symmetric about the deepest minimum at 3.23 hours and rules out all alias periods except possibly a double period with 4 maxima and minima per rotational cycle. This paper, Benishek et al. (2016), Sada et al. (2017), and Pravec et al. (2018) all find rotation periods agreeing within 0.0002 hours. We may be confident that a rotation period both accurate and reliable has been found for 2535 Hameenlinna.

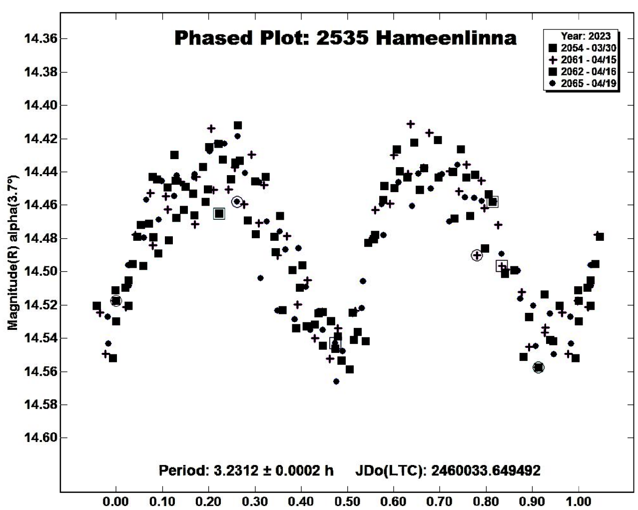

Figure 11. Phased lightcurve of 2535 Hameenlinna.

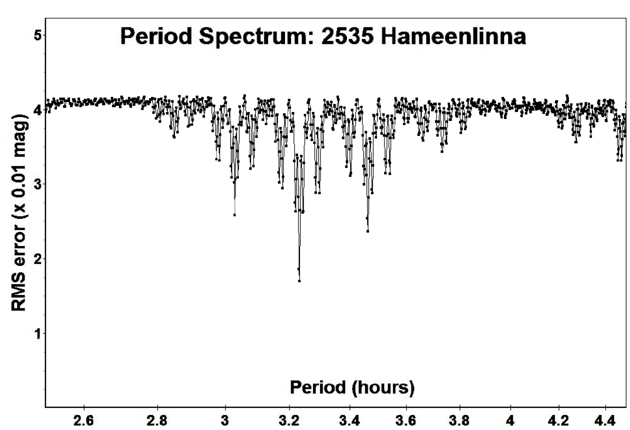

Figure 12. Period spectrum of 2535 Hameenlinna.

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LIGHTCURVE PHOTOMETRY OPPORTUNITIES: 2023 OCTOBER-DECEMBER

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We present lists of asteroid photometry opportunities for objects reaching a favorable apparition and have no or poorly-defined lightcurve parameters. Additional data on these objects will help with shape and spin axis modeling using lightcurve inversion. The “Radar-Optical Opportunities” section includes a list of potential radar targets as well as some that might be in critical need of astrometric data.

We present several lists of asteroids that are prime targets for photometry and/or astrometry during the period 2023 October through December. The “Radar-Optical Opportunities” section provides an expanded list of potential NEA targets, many of which are planned or good candidates for radar observations.

In the first three sets of tables, “Dec” is the declination and “U” is the quality code of the lightcurve. See the latest asteroid lightcurve data base (LCDB from here on; Warner et al., 2009) documentation for an explanation of the U code:

http://www.minorplanet.info/lightcurvedatabase.html

The ephemeris generator on the MinorPlanet.info web site allows creating custom lists for objects reaching V ≤ 18.0 during any month in the current year and up to five years in the future, e.g., limiting the results by magnitude and declination, family, and more.

https://www.minorplanet.info/php/callopplcdbquery.php

We refer you to past articles, e.g., Warner et al. (2021a; 2021b) for more detailed discussions about the individual lists and points of advice regarding observations for objects in each list.

Once you’ve obtained and analyzed your data, it’s important to publish your results. Papers appearing in the *Minor Planet Bulletin* are indexed in the Astrophysical Data System (ADS) and so can be referenced by others in subsequent papers. It’s also important to make the data available at least on a personal website or upon request. We urge you to consider submitting your raw data to the ALCDEF database. This can be accessed for uploading and downloading data at

http://www.alcdef.org