

PERIOD DETERMINATION FOR SLOW ROTATORS (9247) 1998 MO19 AND (66419) 1999 NR13

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Photometric measurements yielding period and amplitude results for asteroids (9247) 1998 MO19 and (66419) 1999 NR13 were performed during their 2013 favorable oppositions. Both asteroids were found to be slow rotators, with synodic rotation periods respectively equal to 11.479 ± 0.001 h and 56.709 ± 0.011 h.

Asteroids (9247) 1998 MO19 and (66419) 1999 NR13 appeared on the CALL web site as asteroid photometry opportunities due to reaching 2013 favorable apparitions and having no defined lightcurve parameters. Unfiltered CCD photometric images were taken at Observatorio Los Algarrobos, Salto, Uruguay (MPC Code I38) using a 0.3-m Meade LX-200R reduced to f/6.9. The CCD imager was a QSI 516wsg NABG (non-antiblooming gate) with a 1536×1024 array of 9-micron pixels and 23×16 arcminute field-of-view. 2×2 binning was used, yielding an image scale of 1.77 arcseconds per pixel. The camera was always worked at -10°C and off-axis guided by means of a SX Lodestar camera and *PHD Guiding* (Stark Labs) software. Image acquisition was done with *MaxIm DL5* (Diffraction Limited). All images were dark and flat-field corrected and then measured using *MPO Canopus* (Bdw Publishing) version 10.4.0.20 with a differential photometry technique. The data were light-time corrected. Night-to-night zero point calibration was accomplished by selecting up to five comp stars with near solar colors according to recommendations by Warner (2007) and Stephens (2008). Period analysis was also done with *MPO Canopus*, which incorporates the Fourier analysis algorithm developed by Harris (Harris *et al.*, 1989).

(9247) 1998 MO19. A total of 10 nights were exclusively devoted to observe this main-belt asteroid from 2013 February 21 through March 17. Imaging exposure was 180 seconds. About 54 hours of effective observation and more than 1,000 data points were required in order to solve the lightcurve. Over the span of observations, the phase angle varied from 11.1° to 8.7° to 8.8° , the phase angle bisector ecliptic longitude from 170.9° to 170.6° , and the phase angle bisector ecliptic latitude from -24.0° to -22.5° . The rotational period was determined (for the first time) to be 11.479 ± 0.001 h along with a peak-to-peak amplitude of 0.35 ± 0.04 mag. Neither clear evidence of tumbling nor binary companion were seen in the lightcurve.

(66419) 1999 NR13. A total of 15 nights were exclusively devoted to observe this Mars-crossing asteroid from 2013 January 19 through February 10. Imaging exposure was 150 seconds. About 82 hours of effective observation and more than 2,100 data points were required in order to solve the lightcurve. Over the span of observations, the phase angle varied from 18.6° to 17.2° to 18.7° , the phase angle bisector ecliptic longitude from 136.5° to 140.4° , and the phase angle bisector ecliptic latitude from -15.6° to -22.2° . The rotational period was determined (for the first time) to be 56.709 ± 0.011 h along with a peak-to-peak amplitude of 0.80 ± 0.05 mag. Neither clear evidence of tumbling nor binary companion were seen in the lightcurve.

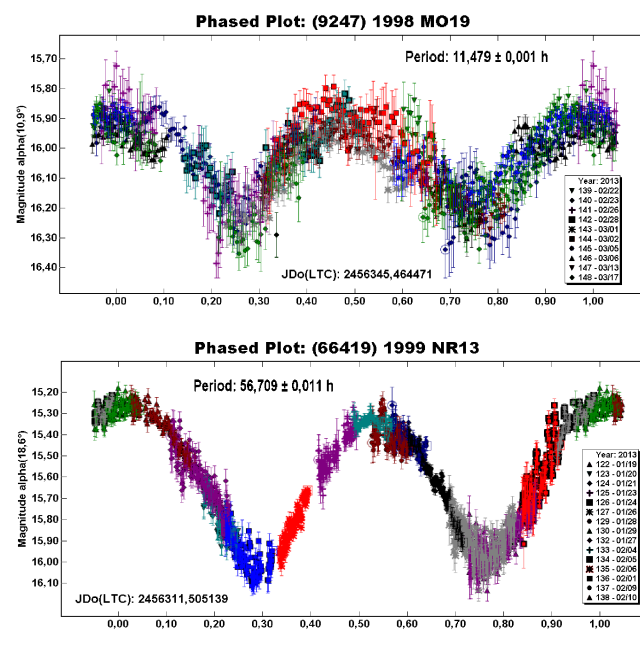
References

Collaborative Asteroid Lightcurve Link (CALL) Web Site at http://www.minorplanet.info/PHP/call_OppLCDBQuery.php

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1024x1024, 24 micron pixels providing 1.25 arc seconds per pixel with a field of view of approximately 22 x 22 arc minutes. The ST-10 with the 0.5x focal reducer used 2x2 binned pixels. The image size was 1092x736 with 13.6 micron pixels. This provided a plate scale of 1.28 arc seconds per pixel and the field of view is approximately 20 x 16 arc minutes. Exposures for all objects were either 180 or 300 seconds depending on the asteroid's brightness. All asteroids were imaged through a clear filter. The CCDs were cooled to -20°C to -30°C depending on the ambient temperature.

The telescopes are controlled and the images are collected with Software Bisque's THEsky V6 and CCDsoft V5. On each night a set of 11 flat field images were median combined and used as a master flat for the flat field process which was done using the batch processing of *MPO Canopus* version 10.4.1.0, Warner (2012). Dark frames were automatically subtracted within CCDsoft while light curves were process with *MPO Canopus*. The synodic periods were obtained within *MPO Canopus* using the Fourier method developed by Harris *et. al* (1989)

Asteroid Summaries

Six asteroids were observed and summaries are presented below. The discovery information and multiple designations were obtained from the JPL Small Body Database Search Engine, (2013). The lightcurves for all of these asteroids can be found in the Asteroid Light Curve Database, ALCDEF, (2013).

852 Waladilena is a main-belt asteroid discovered on 1916 Apr 02 by S. Belyavskij at Simej. It is also known as 1916 S27, A913 SB and A9324 WJ. It was observed on 6 nights between 2013 Jan 18 and 2013 Feb 10. A synodic period of 4.613 ± 0.001 h and an amplitude of 0.29 ± 0.05 mag. was obtained. This asteroid was observed because it was listed as an Inversion Modeling Candidate by Warner *et. al.*, (2013). This asteroid has now been observed at 3 different oppositions with the L_{PAB} and B_{PAB} shown in the table below.

UT date	L_{PAB}	B_{PAB}	Reference
1982 Oct 15	11.0	-8.3	Harris, (1999)
2010 Feb 27	164.7	20.6	Behrend, (2010)
2010 Mar 27	164.1	19.9	Polishook, (2012)
2013 Feb 01	115.0	28.0	this paper

1822 Waterman is a main-belt asteroid discovered at Goethe Link Observatory, Brooklyn, IN on 1950 Jul 25 as part of the Indiana Asteroid Program, IAP, (2013). It is also known as 1950 OO, 1943 EB, 1953 MA and 1963 TT. It was observed on 4 nights between 2013 Jan 19 and 2013 Jan 23. A synodic period of 7.581 ± 0.002 h and an amplitude of 0.51 ± 0.05 mag. was obtained. The light curve has a simple bimodal shape. However while the minima are equal the maxima differ by 0.05 mag.

1827 Atkinson is a main-belt asteroid discovered on 1962 Sep 07 as part of the Indiana Asteroid Program IAP, (2013). It is also known as 1962 RK, 1931 VC, 1955 FI, 1967 TL and 1973 EQ. It was observed on 5 nights between 2013 Feb 16 and 2013 Mar 19. A synodic period of 3.757 ± 0.001 h and an amplitude of 0.24 ± 0.10 mag. was obtained. The night of 2013 Feb 23 has a short series of points with a deviation from the determined curve. These obscurities are believed to be caused by a reported short period of cloud coverage the night of imaging.

2182 Semirov is a main-belt asteroid discovered at Goethe Link Observatory, Brooklyn, IN on 1953 Mar 21 as part of the Indiana Asteroid Program IAP, (2013). It is also known as 1953 FH1, 1937 KF, 1942 FN, 1953 GY, 1955 UT, 1972 TM4, 1975 EU1, 1975

EU3 and 1978 VB8. It was observed on 5 nights between 2013 Jan 31 and 2013 Feb 10. A synodic period of 8.328 ± 0.002 h and an amplitude of 0.32 ± 0.05 mag. was obtained. The lightcurve has a simple bimodal shape.

2334 Cuffey is a main-belt asteroid discovered at Goethe Link Observatory, Brooklyn, IN on 1962 Apr 27 as part of the Indiana Asteroid Program IAP, (2013). It is also known as 1962 HD, 1949 QK, 1955 FK1, 1959 NM, 1962 JQ, 1966 PR and 1982 DK5. It was observed on 3 nights between 2013 Feb 11 and 2013 Feb 14. A synodic period of 5.858 ± 0.002 h and an amplitude of 0.37 ± 0.05 mag. was obtained.

5317 Verolacqua is a main-belt asteroid discovered by C. S. Shoemaker on 1983 Feb 11 at Mount Palomar (MPC 675). It is also known as 1983 CE, 1970 EH, 1983 CB1 and 1987 BF3. It was observed on 7 nights between 2012 Dec 08 and 2013 Feb 02. A synodic period of 3.022 ± 0.002 h and an amplitude of 0.65 ± 0.10 mag. was obtained.

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