## FOUR COLOR OBSERVATIONS OF 2501 LOHJA

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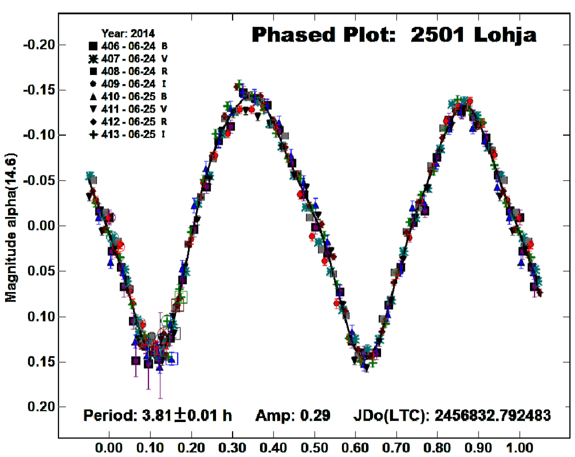
Photometric studies of asteroid 2501 Lohja were made between 2014 June 24 and 25 using the Southeastern Association for Research in Astronomy (SARA) Kitt Peak telescope with Bessell B, V, R and I filters. We obtained a synodic period of 3.81 ± 0.01h, which is consistent with previous values.

All observational data reported here were obtained with the Southeastern Association for Research in Astronomy (SARA) Kitt Peak telescope. This telescope has an aperture of 0.91 m and is located at the Kitt Peak National Observatory near Tucson, Arizona. It has an effective focal ratio of *f*/7.5. When coupled to an Astronomical Research Cameras, Inc, (ARC) CCD camera, the resulting resolution is 0.86 arcsec/pixel (binned 2×2) and the field-of-view (FOV) = 14.6'×14.6'. Bessell BVRI filters were used in turn when taking images. The camera temperature was cooled to –109°C. Image acquisition was done with *DS9*. All images were reduced with master bias, dark, and flat frames. All calibration frames were created using *IDL*. Period analysis was performed using *MPO Canopus,* which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris *et al.,* 1989).

We selected 2501 Lohja to accumulate lightcurve data for shape modeling. We also carried out the photometric studies using B, V, R, I filters to detect possible color variations over the surface of the asteroid. Previously reported synodic periods include Higgins (2006, 3.804 h; 2011, 3.80865 h). Husarik (2014) used lightcurve inversion to find the shape, pole, and sidereal period ($P_{Sidereal}$ = 3.808348 h).




We observed the asteroid on 2014 June 24 and 25 and found color indexes of B-V = 0.94 ± 0.02, V-R = 0.54 ± 0.01, and R-I = 0.382 ± 0.004 mag. No significant differences can be seen among these four color lightcurves. We obtained a synodic period $P$ = 3.81 ± 0.01 h, which agrees with the previously determined values.

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## NEW PHOTOMETRIC OBSERVATIONS OF 128 NEMESIS, 249 ILSE, AND 279 THULE

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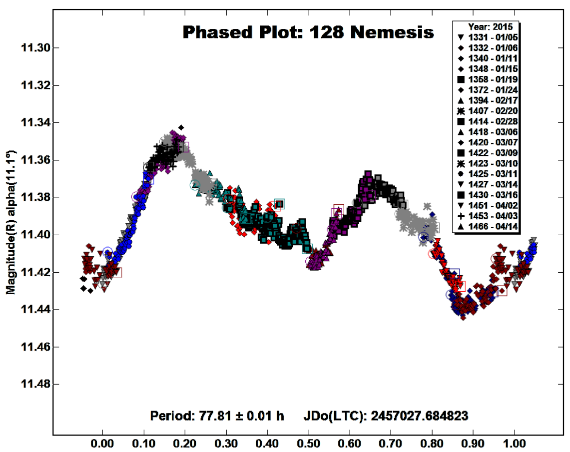
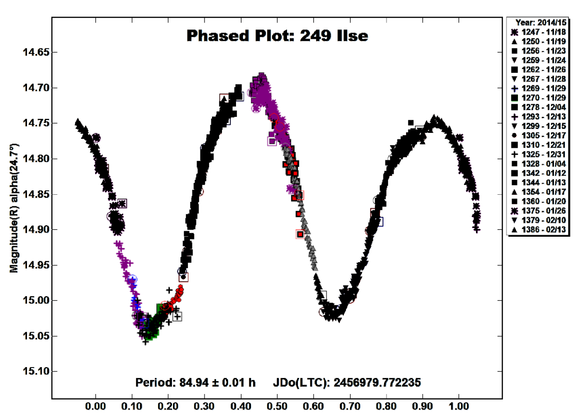
Synodic rotation periods and amplitudes are reported for 128 Nemesis 77.81 ± 0.01 hours, 0.08 ± 0.01 magnitudes; 249 Ilse 84.94 ± 0.01 hours, 0.34 ± 0.02 magnitudes; and 279 Thule, 15.931 ± 0.001 hours, 0.08 ± 0.02 magnitudes.

All observations reported here were made at the Organ Mesa Observatory with a 35 cm Meade LX200 GPS S-C and SBIG STL-1001E CCD, 60 second exposures, unguided. A clear filter was used for 249 Ilse and 279 Thule and R filter for brighter 128 Nemesis. To reduce the large number of data points they have been binned in sets of 3 with maximum time difference 5 minutes for 279 Thule, and in sets of 5 with maximum time difference 10 minutes for 128 Nemesis and 249 Ilse for each of which a total of more than 5000 data points was obtained.

128 Nemesis. Previous photometric observations are by Debehogne et al. (1977) who found a rise of about 0.03 magnitudes on 1976 Sept. 10 0:30 - 7:00 UT and could only infer a fairly long period. Scaltriti et al. (1979) obtained observations on 5 consecutive nights 1977 Dec. 16-20 and obtained a dense unsymmetric bimodal lightcurve with full phase coverage and a good fit to a 39 hour period, 0.1 magnitude amplitude. Although their lightcurve and period look convincing, they estimate an error of ± 0.5 hours due to the short interval of observations. New observations over a much longer time interval were undertaken to confirm the 39 hour period and reduce its error. The pursuit of the next decimal place sometimes yields entirely unexpected behavior that requires us to revise our previously perceived description of nature. The new observations on 19 nights 2015 Jan. 5 – Apr. 14 provide a good fit only to a lightcurve with period 77.81 ± 0.01 hours and amplitude 0.08 ± 0.01 magnitudes. The asymmetry of this lightcurve definitively rules out the 39 hour period by Scaltriti et al. (1979) in favor of a period twice as great.




249 Ilse. Previous photometric observations and derived periods have been published by Binzel (1983), 42.62 hours; Binzel (1987), 85.24 hours; and Angeli et al. (2001), 42.6 hours. All these are based on very sparse data and considered to have low reliability. New observations have been made on 21 nights 2014 Nov. 19 - 2015 Feb. 13 and provide a good fit to an unsymmetric bimodal lightcurve with period 84.94 ± 0.01 hours, amplitude 0.34 ± 0.02 magnitudes.

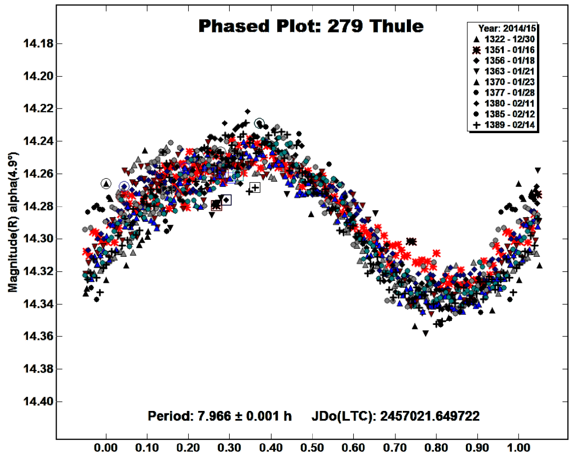


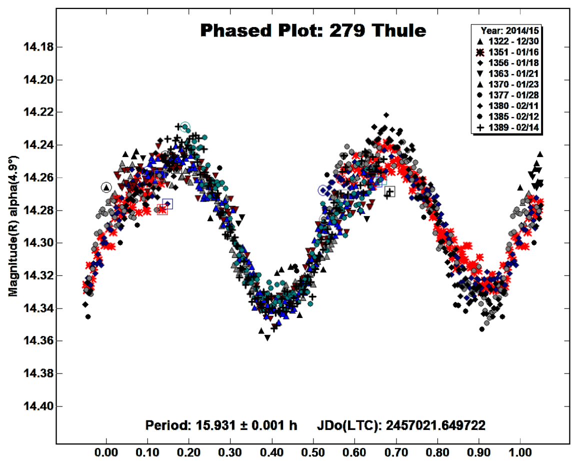

279 Thule. Minor planet 279 Thule is the only large asteroid in a stable 4:3 resonance with Jupiter with a small eccentricity small inclination orbit. Oppositions occur at nearly uniform intervals separated by about 13.5 months and celestial longitudes of about 45 degrees. The magnitude at opposition is always near 14.5. The minimum possible distance from Earth is about 3.24 AU. This makes disk resolved imagery by adaptive optics or radar studies especially difficult, and the only practical means to study its properties is by photometry.

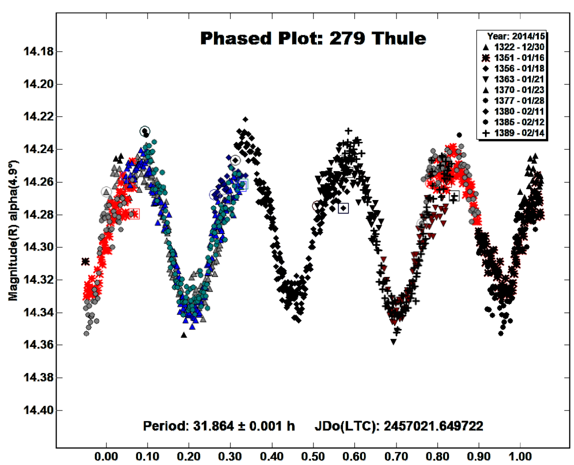
Observations near several previous oppositions have all yielded inconclusive results. The period, amplitude, and celestial longitude of each of these follow, listed in chronological sequence. Zappala et al. (1989) 7.44 h, 0.06 mag, 5 deg; Sauppe et al. (2007), no period found, 0.14 mag, 157 deg; Behrend (2008), 5.75 h, 0.06 mag, 200 deg; Pravec (2008), 11.942 h, 0.04 mag, 200 deg. Warner et al. (2010) published lightcurves phased to both 7.979 h and 15.962 h with amplitude 0.10 mag at celestial longitude 245 deg. The 15.962 hour bimodal lightcurve with a slight asymmetry has a somewhat better fit than the 7.979 hour monomodal lightcurve.

Pilcher (2014) reported additional observations and used the amplitude-aspect method to find an approximate pole orientation. Observations in year 2008 near celestial longitude 200 degrees could be equally well fitted to ambiguous periods of 7.970 hours with monomodal lightcurve and 15.960 hours with bimodal lightcurve and amplitude 0.06 ± 0.02 magnitudes. Observations in 2013 at celestial longitude 70 degrees showed very small amplitude 0.02 magnitudes, and a distinctly monomodal lightcurve phased to 15.85 ± 0.1 hours. In this reference Pilcher also noted the wide range of celestial longitudes of the several investigations, with minimum amplitude at celestial longitude 70 degrees and maximum at celestial longitude 157 degrees. Application of the amplitude-aspect method to determine a rotational pole position suggests it lies within 15 degrees of celestial longitude 70 degrees, latitude 0 degrees, or alternately longitude 250 degrees, latitude 0 degrees. The Asteroid Lightcurve Data File (Warner et al., 2014) states 15.962 hours as the most likely, but not secure, period. Half and twice the most likely period of 15.962 hours are still possible, but all other periods can now be confidently ruled out.

Additional observations were made near the 2014/2015 opposition to provide more data to resolve this ambiguity. It is noted that the possible periods are very nearly Earth commensurate, being 1/3, 2/3, or 4/3 of Earth period. For full lightcurve coverage it necessary to have one-night sessions greater than 8 hours. Nine sufficiently long sessions were obtained 2014 Dec. 30 - 2015 Feb. 14 and spaced so that each segment of the possible 31.864 hour double period was included twice. Lightcurves phased to 7.966 hours, 15.931 hours, 31.864 hours, all ± 0.001 hours, with one, two, and four maxima and minima, respectively, are presented to facilitate discussion. The 15.931 hour lightcurve shows a slight asymmetry between the two maxima and minima, and a slightly smaller scatter of data points than the 7.966 hour lightcurve. The two sides of the 31.864 hour lightcurve are almost identical, and also show the small distinction between adjacent maxima and minima. These all favor the 15.931 hour period with the usual 2 maxima and minima per cycle. The 2013 very small amplitude 15.85 hour monomodal lightcurve is believed to be at near polar aspect, at which circumstance monomodal lightcurves are commonly observed. All the available evidence favors the 15.931 hour period, but not strongly, and this period still cannot be considered reliable.




Future work. The next opposition in 2016 February/March is expected to occur at near equatorial aspect with nearly the maximum amplitude possible, likely near the 0.14 magnitudes reported by Sauppe et al. (2007) at almost the same position in the sky. Observers take note, and please place 279 Thule on your schedule for 2016 February/March. These months represent the best opportunity for many years to come to resolve definitively the rotation period of 279 Thule.

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