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77.

ADDITIONAL LIGHTCURVES OF 165 LORELEY

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Lightcurves of 165 Loreley obtained on three nights in early 2006 can be satisfied by several different rotation periods, one of which, 7.224 hours, is consistent with the tabulated value, with an amplitude of 0.17 mag.

Minor planet 165 Loreley was listed as a target for which additional lightcurves would be useful for shape modeling (Warner et al. 2006). A total of 501 data points were obtained on three nights, 2006 Jan. 15, 26, and Feb. 19. Equipment consisted of a 35 cm Meade LX200 SCT at longitude 89° 53' 48" W, latitude 39° 47' 09" N, altitude 190 meters, SBIG PixCel 237 CCD, unfiltered, differential photometry only. All exposures were 60 seconds in light only mode at CCD operating temperature -20° C. At the end of each night nine each of 60 second darks, 0.5 second dome flats, and 0.5 second flat darks were obtained and respectively median combined for dark and flat correction. The available observations were rather poorly distributed in time and do not yield a unique and unambiguous rotation period. The Jan. 26 sequence was interrupted by a focusing problem, and that of Feb. 19 by about 2 hours as the target passed very close to a somewhat brighter field star.

Image processing was performed with Canopus software by Brian Warner, bdw Publishing Company. On both Jan. 26 and Feb. 19 there was a shift in instrumental magnitude exceeding 0.1 between the data obtained before and after the interruption even although the same comparison stars were used. This we cannot explain, and we measured the image sets from each night as two separate sessions and arbitrarily adjusted the instrumental magnitudes up or down to obtain the best lightcurve fit.

The Canopus software permits a range of trial periods to be fitted by a Fourier series and the rms error for each period within this range to be tabulated and graphed. Local minima within a range

of trial periods correspond to possible synodic rotation periods. In this analysis all periods between 6 and 15 hours, at intervals of 0.001 hour, had rms deviations computed. Lightcurves phased to each of a large number of periods with local rms minima were plotted and inspected visually for goodness of fit. Periods of 7.224 hours, 9.632 hours, 13.515 hours, and 14.448 hours, all $\pm$ 0.001 hours, provided nearly identical rms errors and comparably good fits on those parts of the lightcurve which overlapped on more than one night.

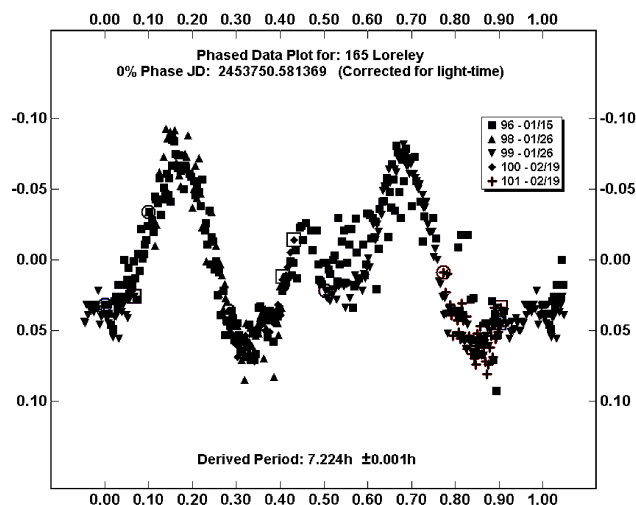
Hence this study by itself does not obtain a unique determination of the synodic rotation period. Harris (2006) stated that he considered a 7.223 hour period to have reliability 3 (secure). Our 7.224 hour period is consistent with this one, and the accompanying figure is phased to 7.224 hours.

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References

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CCD PHOTOMETRY OF ASTEROIDS 276 ADELHEID, 1490 LIMPOPO, AND 2221 CHILTON FROM THE UNIVERSIDAD DE MONTERREY OBSERVATORY

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CCD photometry of asteroids 276 Adelheid, 1490 Limpopo, and 2221 Chilton obtained at the Universidad de Monterrey Observatory during August and September 2005 is reported. A synodic rotation period of 6.315 ± 0.005 hours and an amplitude of 0.17 ± 0.03 magnitudes is confirmed for Adelheid from five nights of observations. The resulting synodic rotation period and amplitude for Limpopo is 6.426 ± 0.003 hours and 0.16 ± 0.03 magnitudes from three nights of observations. Chilton was observed on four nights and exhibits a synodic rotation period of 7.445 ± 0.015 hours and an amplitude of 0.20 ± 0.05 magnitudes, though the period is uncertain due to the faintness of the asteroid in the images. Another possible solution for the rotation period of Chilton is 8.63 ± 0.02 hours.

The observations of 276 Adelheid, 1490 Limpopo and 2221 Chilton reported here were made with the new Meade 36-cm LX200GPS telescope recently acquired for the Universidad de Monterrey Observatory (MPC 720). This telescope was permanently mounted inside a new 6-foot fiberglass dome and is operated from a nearby warm room. The CCD used to gather the data was an SBIG ST-9E with a $512 \times 512 \times 20 \mu\text{m}$ KAF-0261E chip yielding ~ 1.7 arc-seconds per pixel for a field of view of $\sim 14.6' \times 14.6'$ with the aid of an $f/6.3$ focal reducer. The chip temperature was set between -9°C and -12°C depending on ambient conditions.

Two of the targets (Limpopo and Chilton) were selected from a list of asteroid photometry opportunities published by Brian Warner on his Collaborative Asteroid Lightcurve Link (CALL) website (Warner, 2005). The selection criteria used were not very stringent as this was basically a field test for the telescope. Adelheid was chosen because it was bright, it had a known relatively short rotation period, and also could be used for shape/spin modeling determination as suggested by Warner et al. (2005). Limpopo was fainter and there was no literature report on its rotation period, and Chilton was considered at the limit of the system also with no reported rotation period.

Usable data were collected on 2005 August 18, 19, 21, 22 and 26 for 276 Adelheid; August 29 & September 14 and 22 for 1490 Limpopo; and August 22, 24, 25 & September 01 for 2221 Chilton. All dates are UT. In total, 428 images were obtained and processed for Adelheid, 332 for Limpopo and 170 for Chilton. Of these, 360 (84%) were used in the final analysis for Adelheid, 308 (93%) for Limpopo and 170 (100%) for Chilton. The rest were discarded because of asteroid proximity to stars. The auto-guided exposure times were 90 seconds for Adelheid, 120 seconds for

Limpopo and 240 seconds for Chilton. All images were unfiltered. Standard dark current and flat field corrections were applied. Eight stars were used in each image as magnitude comparison. No star fields with photometric standard stars were observed, so all magnitudes are relative to the field comparison stars.

Times were corrected for light travel time from the asteroid to the Earth and were taken to be at the mid-times of the image exposures. Relative magnitudes from night-to-night were uncertain as different comparison star sets were used. This was dealt with by using arbitrary additive constants to bring all the data into the best agreement possible. These magnitude shifts also took into account intrinsic magnitude variation of the asteroids due to their change of distance from Earth, and their phase angle variations (8.5° - 9.0° for 276 Adelheid, 13.2° - 10.8° for 1490 Limpopo [through opposition], and 10.8° - 11.9° for 2221 Chilton).

The best-fit rotational periods for the asteroids were obtained by computing the power spectrum of the time series of data (Scargle, 1982; Horne and Baliunas, 1986). For 276 Adelheid the resulting synodic rotational period was 6.315 ± 0.005 hours with an amplitude of 0.17 ± 0.03 magnitudes (Figure 1). The resulting synodic rotational period for 1490 Limpopo from the data presented here is 6.426 ± 0.003 hours. The amplitude of the lightcurve is 0.16 ± 0.03 magnitudes (Figure 2). For 2221 Chilton the resulting synodic rotational period was 7.445 ± 0.015 hours with an amplitude of 0.20 ± 0.05 magnitudes (Figure 3). However, Chilton was at the practical working magnitude limit of the system and the noise in the data was larger than desired. Another possible rotation period for this asteroid derived from the power spectrum could be 8.63 ± 0.02 hours. Adelheid and Limpopo exhibited two slightly different maxima and minima per rotation, while the lightcurve for Chilton seems symmetric. The time scale is given in rotational phase with the zero corresponding to the epoch, in Julian Day, indicated in each figure.

This is probably the first reported rotational period for 2221 Chilton since it is not listed in A. Harris and B. Warner's 'Minor Planet Lightcurve Parameters' list (Harris and Warner, 2006). 1490 Limpopo was also observed in 2005 by L. Bernasconi on five nights between August 26 and September 01, and a rotation period of 6.647 ± 0.004 hours is reported in Behrend's "Asteroids and Comets Rotation curves" webpage (2006). When applied to our data this rotation period also yields a reasonable lightcurve. We note that in our analysis two other periods that flanked our chosen result also yielded good lightcurves, though they had slightly less power. These were 6.217 ± 0.003 and 6.650 ± 0.003 hours. The second one coincides with Behrend's reported period, but we choose to report our initial result since it has slightly higher power than the neighboring periods and our data spans a larger time period.

Asteroid 276 Adelheid has been previously observed. Carlsson and Lagerkvist (1983) first report photoelectric observations, though they could not derive a rotation period from their three nights of observations. Piironen et al. (1994) observed the asteroid over 8 nights in October and November of 1984 and derived a rotation period of about 6.32 hours that they consider in good agreement with a 6.328 hour period previously reported, according to them, by Dotto et al. (1992a). That reference does not contain photometry for 276 Adelheid and they probably meant to reference Dotto et al. (1992b). This same last group (Di Martino et al. 1995) report observations in 1992 February and March that confirm their initial 6.328-hour period with an uncertainty of ± 0.012 hours and an amplitude of 0.10 ± 0.02 magnitudes. Wang and