

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

Shi (2002) report a less-precise rotation period of 6.29 ± 0.01 hours. The last published observation of 276 Adelheid is by Pray (2005) and he reports a rotational period of 6.315 ± 0.002 hours and an amplitude of 0.17 ± 0.02 magnitudes from observations performed between June 13 and 22, 2004. The rotation period and amplitude presented here for 276 Adelheid matches remarkably well the ones reported by Pray.

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