

LIGHTCURVES AND PERIOD DETERMINATION FOR 817 ANNIKA

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Minor planet 817 Annika was observed from several sites across Australia over a period of 14 days (29 rotations) during Oct. and Nov., 2002. Lightcurves obtained on 9 nights with unfiltered CCDs have yielded a rotational (synodic) period of 10.560 ± 0.004 hrs. The complete lightcurve exhibits two maxima and two minima, with a total amplitude range of 0.29 ± 0.02 magnitudes.

Introduction

Annika was discovered by Max Wolf at Heidelberg on Feb 6, 1916. Its original provisional designation was 1916 YW. The origin of the name remains unrecorded. The absolute magnitude (H) is quoted as 10.8 with a moderately high albedo of 0.13, while its estimated diameter is given as 25 ± 2.2 km (Tedesco, 1989). Its taxonomic class remains unknown, but its position in the middle of the main belt (dynamical family 148) suggests a C, M, A or T type. The moderately high albedo would appear to rule out C or T, thus implying an M or A type. The latter are rather rare, so an M type classification appears probable (cf stony-iron meteorites). Annika was chosen from the suggested targets in the observing list of Pravec et al. (2002). The most recent tabulation examined for previous lightcurve data was that of Harris (2001), but no lightcurve data are listed there.

Observations

At this opposition Annika was at Declination -12° making it a convenient target for southern hemisphere observers. Observations were made as a collaborative effort from several widely scattered locations across Australia (Table I). The 40cm SCT and ST8 CCD camera at the Mt Tarana Observatory site (observer Bembrick) near Bathurst, NSW, have previously been documented by Bembrick (2001). In this project Bolt utilized a 25cm SCT and ST7 CCD camera from a site near Perth, WA. Near Melbourne, Richards used an 18cm refractor with an ST7e camera. The locations of all the observers are tabulated below:

To the best of our knowledge, this is the first Australia-wide collaboration of amateurs in the investigation of minor planet lightcurves and periods. Other collaborations – e.g. Bembrick et al., 2002 – have been of a more local nature.

The observational circumstances for 2002 are presented in Table II, which also shows the percent of the rotational lightcurve covered on each night and the observer(s) involved.

Table I. Location of Observers

Observer	Lat	Long	Height (m)	Obs. No.
C. Bembrick	S 33.4348	E 149.7576	880	1
G. Bolt	S 31.7906	E 115.7571	45	2
T. Richards	S 37.7156	E 145.1673	100	3

Table II. Observational Circumstances

Date	Obs	Hel.	Hel.	R	Solar	Phase
2002	No.	Lat. (B°)	Long. (L°)	(AU)	Phase Angle	Coverage (%)
Oct 24	2	-20.01	017.40	2.165	10.75	66
Oct 28	1	-19.91	016.57	2.162	11.95	40
Oct 29	1	-19.88	016.37	2.161	12.28	46
Oct 30	2	-19.84	016.18	2.160	12.61	61
Oct 31	1&3	-19.79	015.99	2.159	12.94	40
Nov 02	2	-19.69	015.64	2.158	13.63	66
Nov 03	2	-19.64	015.4	2.157	13.98	70
Nov 04	1	-19.58	015.31	2.156	14.33	52
Nov 06	3	-19.45	015.01	2.155	15.03	43

The benefits from collaboration are evident here in the high number of nights of “back-to-back” observations – essential for the elimination of aliases in the period search.

Discussion of Results

The data from each night were plotted as differential instrumental magnitude vs. JD. No light-time corrections were applied. The epoch of zero phase was chosen as the prominent minimum of November 3rd (JDGeo 2452582.1454). In all, 18 extrema were identified from the lightcurves and the time differences between these were used to estimate the rotational period. This led to an initial estimate of 10.57 hours.

This initial estimate was refined by using a Fourier analysis technique (Belsere, 1988) to conduct a period search, centered on the initial estimate, with data from all nine nights. One of the best frequencies was found to be 2.272 (cycles/day), which is a period of 0.440 days (10.560 hours), in close agreement with the initial interpretation. The Fourier analysis also found periods of 0.220 and 0.282 days. However phase stacking using the latter period did not produce an acceptable composite lightcurve and this was rejected as an alias. The former period (0.220) is of course

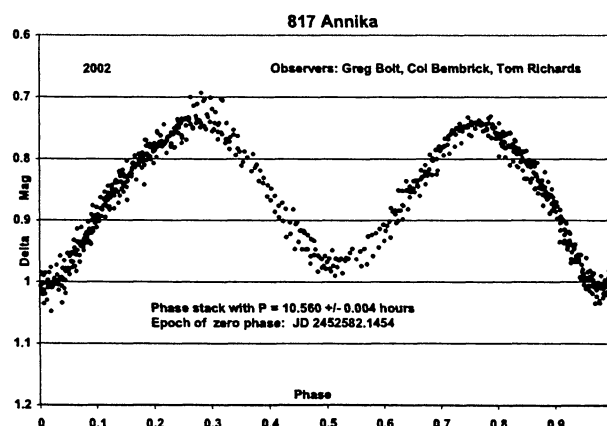


Figure 1. Lightcurve for 817 Annika based on a rotational period of 10.560 ± 0.004 hrs.

half the true period and a phase stack produces a lightcurve with only one maximum.

On this basis the observations cover 29 rotational cycles. Using the above epoch and refined period, the data were phase folded (Fig. 1), with the magnitudes of the primary minima from other nights being adjusted to the magnitude of the zero phase minimum on the night of epoch. Results were posted on the CALL website on December 11, 2002.

The average amplitudes of the extrema were estimated from the composite curve. The overall peak-to-peak amplitude of this lightcurve is 0.29 magnitudes. To a first approximation, the maximum amplitude of 0.29 magnitudes implies a ratio a/b of 1.30, where a , b and c are the semi-axes of a tri-axial ellipsoid and the rotation is about the shortest axis, c .

Conclusions

Minor planet 817 Annika was observed over 29 rotational cycles and the synodic period determined as 10.560 ± 0.004 hours. This is a secure result as all rotational phases of the lightcurve were observed with a high density of points (Fig 1).

The maximum amplitude of the lightcurve at this opposition was 0.29 ± 0.02 magnitudes. The difference between the two maxima was only 0.02 magnitudes, implying a very small difference in albedo between the opposite hemispheres.

The revolution rate of 2.272/day indicates that Annika is fairly typical among the asteroids of less than 50 km diameter. This group of asteroids may have a bi-modal distribution of rotation rates peaking at approximately one rev/day and at approx 3 rev/day (Binzel et al. 1989).

The relatively large amplitude and "clean" lightcurve suggest that this asteroid is a good target for future additional lightcurves aimed at pole orientation studies.

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LIGHTCURVE ANALYSIS FOR ASTEROIDS 436 PATRICIA, 3155 LEE, 4254 KAMEL, 5940 FELIKSOBOLEV, (16558) 1991 VQ2, AND (45656) 2000 EE45

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Lightcurve measurement and analysis of six asteroids was performed at the Palmer Divide Observatory at various times in 2002 and early 2003. The results, all synodic periods, were: 436 Patricia, 16.133h ± 0.005 h, amplitude 0.30 ± 0.02 m; 3155 Lee, 8.312h ± 0.002 h, amplitude 0.22m ± 0.02 m; 4254 Kamel, 2.739h ± 0.002 h, amplitude 0.17m ± 0.02 m; 5940 Felixsolev, 6.578h ± 0.002 h, amplitude 0.23m ± 0.02 m; (16558) 1991 VQ2, 37.37h ± 0.02 h, amplitude 0.22m ± 0.02 m; and (45656) 2000 EE45, 6.4h ± 0.5 h, amplitude 0.4m ± 0.05 m. Of particular interest is the Vesta family member 3155 Lee, which proved to have four minima and maxima per rotation suggesting a highly irregular shape.

Asteroid lightcurve work has been the main focus at the Palmer Divide Observatory since 1999 April. Since that time the period and amplitudes of more than 50 asteroids have been measured. The current instrumentation consists of two telescope/camera combinations. First (Scope A) is a 0.5m Ritchey-Chretien working at f/8.1 using a Finger Lakes Instrumentation camera using the Kodak KAF-1001E non-antiblooming CCD chip working at -30°C and 2x2 binning (0.48um pixels). This yields a scale of about 2.4 arcseconds per pixel. Given that the average seeing at the Palmer Divide Observatory is on the order of 4-5 arcseconds, this is usually a satisfactory match. The second combination (Scope C) is a 0.3m f/9.3 Schmidt-Cassegrain using an SBIG ST-9E working at 1x1 binning. This yields a scale of about 1.45 arcseconds per pixel. All observations for this paper were unfiltered. All images were dark subtracted and flat-fielded before measuring.

Initial targets are determined by referring to the list of lightcurves maintained by Dr. Alan Harris (Harris 2001), with additions made by the author to include findings posted in subsequent issues of the Minor Planet Bulletin. In addition, reference is made to the Collaborative Asteroid Lightcurve Link (CALL) web site maintained by the author (<http://www.MinorPlanetObserver.com/astlc/default.htm>) where researchers can post their findings pending publication.

MPO Canopus, a custom software package written by the author, is used to measure the images since it allows automatic storage of the measured (instrumental and derived) magnitudes of the comparison stars and targets. It uses aperture photometry with derived magnitudes determined by calibrating images against field or, preferably, standard stars. A utility program can be used to convert the instrumental magnitudes to a standard system. The package includes a Fourier analysis routine, the original FORTRAN code for which was supplied by Alan Harris (Harris et al, 1989) and converted to Delphi Pascal. If the data from a single night appears to cover at least half a period or more, then an