CCD PHOTOMETRY OF ASTEROIDS (58) CONCORDIA, (360) CARLOVA AND (405) THIA

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Abstract. Three selected asteroids, numbered 58, 360 and 405, were observed during 2000 at Yunnan Observatory, China. The new lightcurves are presented in this paper. The synodic period of (58) Concordia is estimated as 9.90 ± 0.01h for the first time. The synodic period of (405) Thia derived from our observation is 9.96 ± 0.01h, which is slightly different from the previous result. For 360, we obtained the synodic period of 6.18 ± 0.02h which is consistent with previous values. Additionally, the BV and UB-colour indexes for the three asteriods were also determined.

Keywords: Asteroids, CCD photometry, synodic period

1. Introduction

Photometric observations provide data for the determination of rotational periods, orientations of spin vector and the physical properties of the surface of the asteroids. The precision of the photometry of asteroids has been improved due to the use of CCD detector. With the large field of view of the CCD camera, we can observe the asteroid and comparison stars in the same frame simultaneously. All these factors make it reliable to observe some asteroids which have low amplitude when rotating around their spin axis.

To some extent, the accurate spin period of an asteroid provides the basis for modeling its triaxial ellipsoidal shape, and also evidence for studying the theory of asteroid collision evolution.

For the purpose of extending the photometric database and providing constraints on the collisional evolution model, large number of photometric observations, especially observations of particular asteroids are needed.

In our observation program, we have concentrated on the asteroids without definite rotation periods, and also on those without a definite orientation of the spin vector, or lack of data in these aspects. In this paper, we provide lightcurves for three selected asteroids and their synodic rotational periods.

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TABLE I
Aspect data

Asteroid	Date (UT)	r (AU)	Δ (AU)	α (degree)	λ, β (2000.0) (degree)
(58) Concordia	2000/12/22.6	2.748	1.810	7.6	70.678, −7.638
	2000/12/23.6	2.747	1.814	8.0	70.481, −7.616
	2000/12/24.6	2.747	1.819	8.4	70.280, −7.590
(360) Carlova	2000/11/15.6	2.497	1.629	13.6	21.506, −17.894
(405) Thia	2000/11/14.6	3.176	2.223	5.7	36.572, +9.623
	2000/11/16.6	3.175	2.230	6.3	36.135, +9.512

2. Observation

The observations of three selected asteroids were made with the 1-meter telescope at Yunnan Observatory, China in 2000. The asteroid (58) Concordia was observed on 22, 23 and 24 December 2000, (405) Thia on 14 and 16 November 2000, and (360) Carlova on 15 November 2000, respectively. The photometric data were collected with a CCD camera through standard U, B and V filters.

The CCD frames were reduced with standard IRAF (Image Reducation Analysis Facility) procedures. The magnitudes of the asteroids and comparison stars were determined by aperture photometry after the images were corrected for bias and flat-field. For asteroids that overlapped other stars during the period of observation, DAOPHOT procedures (subtracting the adjoining stars from the images) were applied before the aperture photometry determination.

In order to obtain the BV and UB-colour indexes, we observed some of the photometric standard stars of Landolt (1983, 1992), and reduced the resulting magnitude to the standard photometric system with IRAF procedures.

Observing conditions for the three asteroids are listed in Table I, including date of observation, geocentric distance and heliocentric distance both in astronomic units, phase angle, ecliptic longitude and latitude in 2000.0 reference.

3. Results

In order to find out the synodic rotational period of (58) Concordia, we used the MUFRAN(MUlti Frequency ANalysis) program (Kolláth, 1990) to analyze the observational data, and derived the possible period. Taking this period as initial value, we applied the PDM (Period Determination using phase dispersion Minimization) method (Stellingwarf R., 1978) to estimate the accurate value of period. With the selected period value, we combine all observation data obtained on different nights

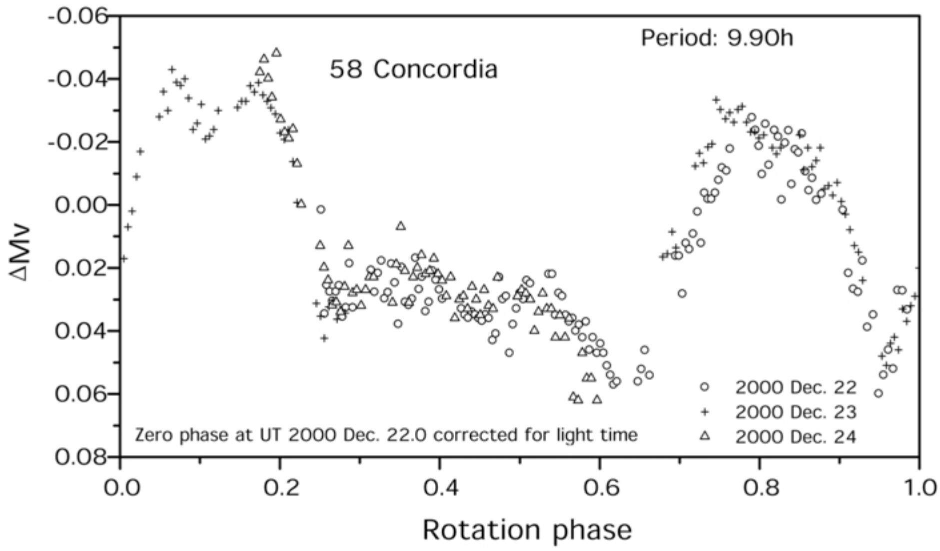

Figure 1. The lightcurve of (58) Concordia. ΔM_v represents the magnitude difference between asteroid and comparison star.

into one period lightcurve with minimum phase dispersion, and the corresponding value of dispersion was used to estimate the error of the period. By this process, the relative suitable synodic rotational periods of (58) Concordia, (360) Carlova and (405) Thia, were ascertained.

3.1. (58) Concordia

(58) Concordia, the low-numbered asteroid of type C, has been observed previously by Gil Hutton (1993). Due to limited data, no definite period was provided. From our three nights observations, we found a synodic period of 9.90 ± 0.01 h with an amplitude of $0^m.11$, and constructed a composite lightcurve (Figure 1) with this period. In addition, for the sake of check to the data, Dr. P. Pravec estimated a period of 9.89 ± 0.01 using the method of Harris and Young (1989). The B-V and U-B color indexes are estimated as 0.70 ± 0.01 and 0.45 ± 0.01, respectively. The value of B-V is slight larger than the values given by Tedesco (1989) and Gil Hutton (1993), 0.69 and 0.67 ± 0.01, respectively.

The lightcurve of 58 shows a very irregular shape with two different height maxima. There is a distinct sunken part at the top of primary maximum. In order to derive the orientations of spin vector, and the properties of its surface continuous observations are necessary.

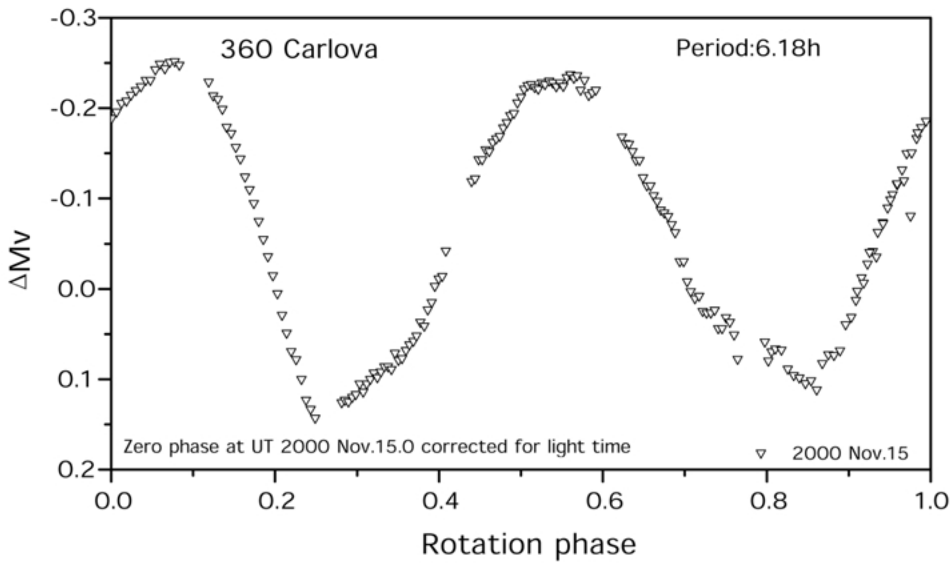

Figure 2. The lightcurve of (360) Carlova. ΔM_v represents the magnitude difference between asteroid and comparison star.

3.2. (360) CARLOVA

Photometric observations of this asteroid have been made many times previously. Harris and Young (1983) provided a rotational period of 6.21 h with an amplitude of $0^m.37$. Di Martino et al. (1987) reported a rotational period of 6.183 h. Dotto et al. (1995) obtained an asymmetric lightcurve with an amplitude of $0^m.33$. Michalowski et al. (2000) observed this object serval times, once in January 1996 from which they only obtained an amplitude of $0^m.44$, and again in March 1997 and May 1998. The period obtained from these observations is the same, 6.188 hours, but the amplitude from the two observations is different, $0^m.30$ and $0^m.49$, respectively.

We observed this asteroid on 15 November 2000, the observation lasts near 7 h. With the synodic period of 6.18 ± 0.02 h we could construct the composite lightcurve (Figure 2) well. The amplitude at this time is $0^m.40$. The B-V and U-B color indexes obtained from our UBV photometric data are 0.68 ± 0.04 and 0.28 ± 0.04, respectively, which are consistent with previous values. With other lightcures observed in different aspect, we will determine its spin orientation in further work.

3.3. (405) THIA

Harris and Young (1980) reported an unambiguous period of 10.08 ± 0.07 h. From our observations on two nights, we derived the synodic period of 9.96 ± 0.01 h for which the phase dispersion of the composite lightcurve reaches minimum (Figure 3). At this time, the amplitude is $0^m.25$ which means the asteroid was more equator-

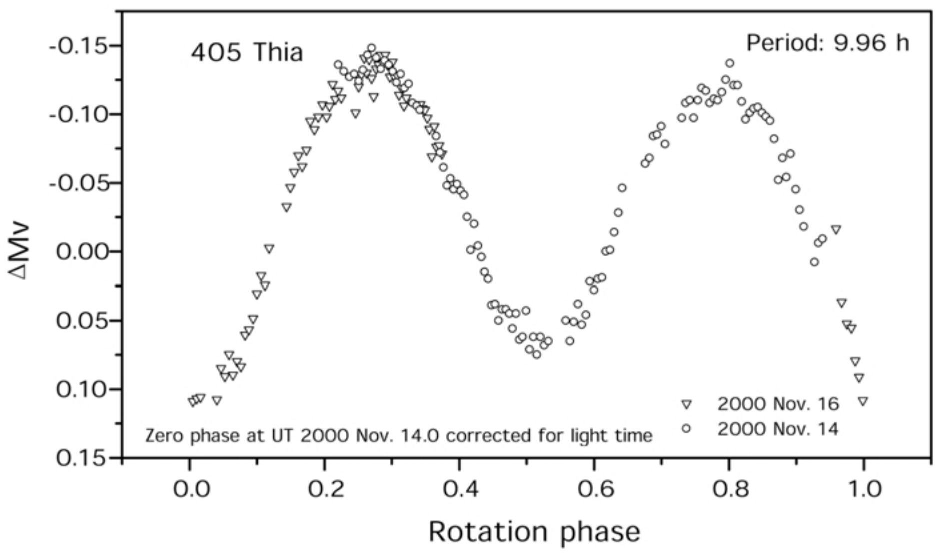

Figure 3. The lightcurve of (405) Thia. ΔM_v represents the magnitude difference between asteroid and comparison star.

on in our observation than in Harris and Young's (1978) observations. The B-V and U-B color index are 0.67 ± 0.02 and 0.37 ± 0.04, respectively, which are consistent with the values given by Tedesco (1989). From the lightcurve, the slight difference between two maxima can be resolved, the primary maximum being slightly sharper than the secondary maximum.

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