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PHOTOMETRY OF ASTEROIDS 558 CARMEN, 613 GINEVRA, AND 1124 STROOBANTIA

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RESUMEN

Se presenta fotometría CCD de los asteroides 558, 613 y 1124, obtenida durante cuatro períodos de observación en 1993 y 1995. Se han determinado los siguientes períodos sinódicos de rotación: 558 Carmen (9.264 ± 0.005 horas), 613 Ginevra (16.45 ± 0.01 horas) y 1124 Stroobantia (16.39 ± 0.01 horas).

ABSTRACT

CCD photometry of asteroids 558, 613 and 1124 are herein presented, which was obtained during four observing periods on 1993 and 1995. We have determined the following synodic rotational periods: 558 Carmen (9.264 ± 0.005 hours), 613 Ginevra (16.45 ± 0.01 hours) and 1124 Stroobantia (16.39 ± 0.01 hours).

Key words: **MINOR PLANETS**

1. INTRODUCTION

Enlarging the observational data base of rotational properties of asteroids may allow significant conclusions to be drawn regarding the collisional evolution of the asteroid belt (Chapman et al. 1989; Binzel et al. 1989; Davis et al. 1989 and references therein) and gain insights into the cosmogonically important distribution of spin axis orientation (Magnusson 1986). It was suggested, on the basis of the available data on asteroids, that the outcomes of collisions are strongly dependent on size. Asteroids with diameters larger than 150 km have mostly "pile of rubble" structures (Davis et al. 1979) forming a group of bodies dominated by self-gravitation, but objects smaller than 100 km in diameter are mostly multigeneration fragments whose shape is controlled by solid-state forces only. In the available data on the rotational properties of asteroids, the prominent problems are the inaccuracy of the rotational parameters for some of the large objects, the presence of selection effects for the intermediate-size objects, and a serious lack of information for asteroids smaller than 50 km. Compared with the known population of asteroids, only about 10% of those with diameters less than 50 km have well determined rotational properties, while this percentage is 40% for objects between 50 and 200 km.

With this point in mind, we have performed a regular photometry program of asteroids whose main goal is the lightcurve determination for asteroids smaller than 200 km in diameter (Gil-Hutton 1988). The present paper summarizes lightcurve data for asteroids 558 Carmen, 613 Ginevra and 1124 Stroobantia from four observing runs during 1993 and 1995.

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2. OBSERVATIONS

The observations of asteroids 558 and 613 were made with the 76-cm cassegrain telescope of Estación Astronómica "Dr. Carlos Ulrrico Cesco" of Félix Aguilar Observatory, San Juan, Argentina and a 2x2-binned Texas Instruments 1024 X 1024 CCD camera, giving an image scale of 0.4 arcsec per binned pixel and a field of view of 3.4 arcmin. The asteroid 1124 was observed with the 2.15-m telescope at Complejo Astronómico El Leoncito (CASLEO), San Juan, Argentina with a 2x2-binned Tek 1024 x 1024 CCD camera, giving an image scale of 0.52 per binned pixel and a field of view of 4.4 arcmin. Typical positional uncertainties of $\pm$ 0.5 arcmin usually allowed to locate the asteroid within an image frame centered on the predicted position. An asteroid's identity was certified through detection and measurement of its

TABLE 1

OBSERVING CONDITIONS

Asteroid	Date	λ (2000.0)	β	α	Δ	r
558 Carmen	Feb 24 1995	218.47	08.71	−17.6	2.361	2.935
	Feb 26 1995	218.55	08.84	−17.3	2.337	2.935
	Feb 27 1995	218.58	08.90	−17.2	2.325	2.936
	Feb 28 1995	218.61	08.97	−17.0	2.313	2.936
	Apr 21 1995	212.30	11.67	−04.0	1.965	2.955
613 Ginevra	Jul 20 1995	314.82	−08.29	−06.6	2.002	2.979
	Jul 23 1995	314.26	−08.26	−05.6	1.990	2.977
	Jul 25 1995	313.87	−08.24	−05.0	1.982	2.976
1124 Stroobantia	Oct 08 1993	354.00	−04.30	07.2	1.934	2.888
	Oct 09 1993	353.83	−04.25	07.6	1.939	2.888
	Oct 10 1993	353.66	−04.20	07.9	1.945	2.889
	Oct 11 1993	353.49	−04.15	08.3	1.951	2.889

motion vector. Due to the brightness of the target asteroids, always in the range $V = 14$ to 15, the telescope was tracked at sidereal rate and exposures of 180 s to 300 s were used. Differential photometry in the standard V and B magnitudes was carried out using background stars as local comparisons due to their closeness to the asteroids. For asteroids 558 and 1124, those stars were standardized by using equatorial standards from Landolt (1973, 1983), but for the asteroid 613, the stars were not been standardized due to the presence of thin cirrus clouds during the observing runs.

Flat field images were obtained using the evening and morning twilight sky. More than ten bias frames were obtained during the course of each night to monitor the noise level of the CCD, where the mean remained constant to within less than 1 ADU. Also, five dark frames with exposures greater than 300 s were obtained each night to test the dark current of the chip, but its mean remained constant at the bias level. All image processing, including bias and dark subtraction and flat field corrections, was performed using the Image Reduction and Analysis Facility (IRAF) software package developed by the National Optical Astronomy Observatories (NOAO). Magnitudes for the asteroid and at least two comparison stars were extracted from each image using the technique of aperture photometry.

Aspect data for all observing nights are given in Table 1 including the date, geocentric longitude (λ) and latitude (β) of the asteroid, its phase angle (α) and its geocentric (Δ) and heliocentric (r) distances. The observations were corrected for light-time and the mean error of the single measurements is 0.01 magnitude.

3. RESULTS

To search for rotational periods the data obtained were analized using the Phase Dispersion Minimization (PDM) method proposed by Stellingwerf (1978), which is a generalization of Lafler & Kindman (1965) method and allows an arbitrary degree of smoothing and provides complete statistical information. The data about taxonomic classification is from Tholen (1989).

3.1. *558 Carmen*

This M-type asteroid was observed previously by Harris & Young (1979, 1989) and Harris et al. (1992) who suggest a period estimate of about 10 hours. Five nights of observations show that this reported period is not correct, but using the data presented here, it was possible to construct a composite V lightcurve (Figure 1) and find a rotational period of 9.264 ± 0.005 hours, which agrees very well with the data obtained previously. The lightcurve shows an amplitude of 0.31 ± 0.01 mag and unequal maxima and minima, a typical feature of M-type objects. The $(B - V)$ color index observed was 0.74 mag, which

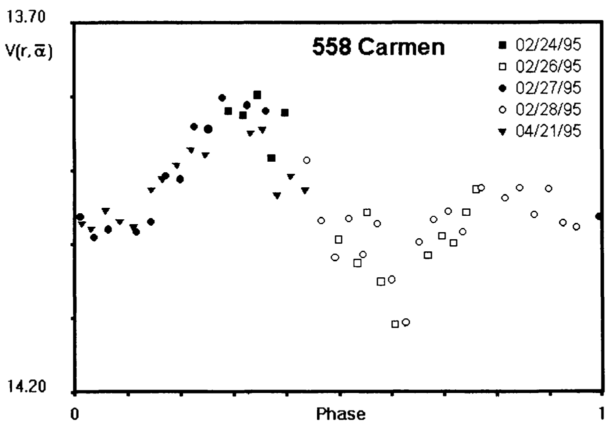

Fig. 1. Composite V lightcurve for asteroid 558 Carmen using a synodic period of 9.264 hours. The zero of rotational phase corresponds to 02/24/95 at 0 hours UT.

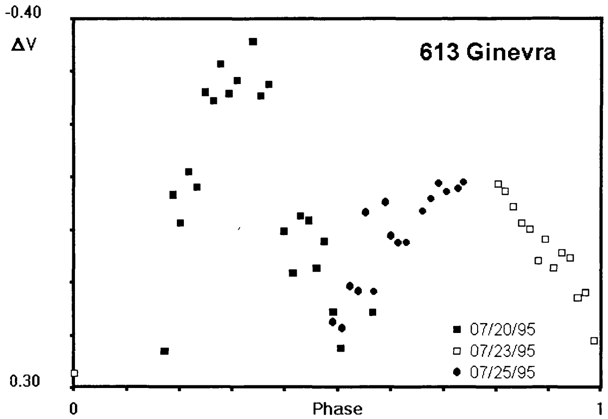

Fig. 2. Composite *V* lightcurve for asteroid 613 Ginevra using a synodic period of 16.45 hours. The zero of rotational phase corresponds to 07/20/95 at 0 hours UT.

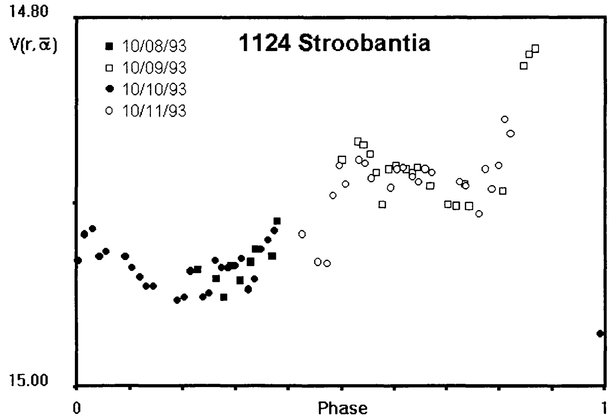

Fig. 3 Composite *V* lightcurve for asteroid 1124 Stroobantia using a synodic period of 16.39 hours. The zero of rotational phase corresponds to 10/08/93 at 0 hours UT.

is in excellent agreement with the value reported by Tedesco (1989), namely 0.73 mag.

3.2. *613 Ginevra*

This P-type asteroid had never been previously observed photometrically. Using the data obtained during three nights in 1995, it was possible to determine a rotational period of 16.45 ± 0.01 hours. The composite *V* lightcurve (Figure 2) has a light variation of 0.63 ± 0.02 mag and shows a principal maximum which is brighter by about 0.2 magnitude compared with the secondary maximum. The minima are also unequal, but the secondary minimum is not well represented due to poor coverage of this part of the rotational phase, but looks deeper than the other.

3.3. *1124 Stroobantia*

No photometric observations exist in the literature for this X-type asteroid, but using the data obtained during four nights in 1993 it was possible to obtain a period of 16.39 ± 0.01 hours. Figure 3 shows the composite *V* lightcurve which is complex and has a light variation of 0.15 ± 0.01 mag, with a secondary maximum suggested around rotational phase 0.4. The secondary minimum is not well represented due to poor coverage of this part of the rotational phase. This type of asymmetric lightcurve is typical of a collisional fragment, which is also suggested by its small diameter of 24 km (Tedesco 1989). The $(B-V)$ color index observed was 0.71 mag, 0.01 mag higher than the value listed by Tedesco (1989), and it does not show any appreciable modulation versus the rotational phase.

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REFERENCES

Binzel, R., Farinella, P., Zappalá, V., & Cellino, A. 1989, in Asteroids II, ed. R. Binzel, T. Gehrels, & M. Shapley Mathews, (Tucson: Univ. of Arizona Press), 416
Chapman, C. R., Paolicchi, P., Zappalá, V., Binzel, R., & Bell, J. 1989, in Asteroids II, ed. R. Binzel, T. Gehrels, & M. Shapley Mathews, (Tucson: Univ. of Arizona Press), 386
Davis, D. R., Chapman, C. R., Greenberg, R., Weidenschilling, S., & Harris, A. W. 1979, in Asteroids, ed. T. Gehrels, (Tucson: Univ. of Arizona Press), 528
Davis, D. R., Weidenschilling, S., Farinella, P., Paolicchi, P., & Binzel, R. 1989, in Asteroids II, ed. R. Binzel, T. Gehrels, & M. Shapley Mathews, (Tucson: Univ. of Arizona Press), 805
Gil-Hutton, R. 1988, Minor Planet Bull. 15, 3
Harris, A. W., & Young, J. W. 1979, Icarus 38, 100
__________. 1989, Icarus 81, 314
Harris, A. W., Young, J. W., Dockweiler, T., Gibson, J., Poutanen, M., & Bowell, E. 1992, Icarus 95, 115
Lafler, J., & Kinman, T. D. 1965, ApJS, 11, 216
Landolt, A. U. 1973, AJ, 78, 959
__________. 1983, AJ 88, 439
Magnusson, P. 1986, Icarus 68, 1
Stellingwerf, R. F. 1978, ApJ 224, 953
Tedesco, E. F. 1989, in Asteroids II, ed. R. Binzel, T. Gehrels, & M. Shapley Mathews, (Tucson: Univ. of Arizona Press), 1090
Tholen, D. J. 1989, in Asteroids II, ed. R. Binzel, T. Gehrels, & M. Shapley Mathews, (Tucson: Univ. of Arizona Press), 1139

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