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Photometry of Karin family asteroids

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Abstract. We have performed photometric observations in the V-band of two asteroids belonging to the Karin asteroid family, (11728) Einer and (93690) 2000 VE_{21}, using the 2-m Himalayan Chandra Telescope, Hanle and 2k × 4k pixels CCD imager. We obtained measurements during two nights (November 25 and 26, 2005) which enabled information on the rotational periods and the lightcurve amplitudes of the asteroids to be derived. In addition, we derived the absolute magnitudes H, improving previously published values. These observations were performed to complement the IR observations obtained for a set of Karin family asteroids with the Spitzer space telescope.

Keywords : asteroids– photometry– solar system

1. Introduction

Asteroid families are thought to be produced from asteroid collisions, with the ejected fragments making up the members of the family. They are identified via their similar proper orbital elements (see e.g. Bendjoya and Zappalà, 2002 for a review). The number of observed families and their production rate can be used to constrain the collisional history of the main belt (Bottke et al., 2005a; Bottke et al., 2005b). One of the crucial factors is the age of a family and it is therefore important to determine the time at which the collisional event occurred. This can be done in various ways, one being tracking back the evolution of the orbital elements to a common starting point at which the family members have similar orbital parameters. However, this works reliably only for young

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families, because different mechanisms limit the reliability of orbital integrations over long time periods

Recently, the effects of non-gravitational perturbations, like the Yarkovsky forces have been successfully modelled, thus allowing the ages of a few very young families to be determined, including the Karin family. Nesvorný et al. (2002) determined that the Karin cluster, a group of asteroids produced by the disruption of a 30-km diameter body, is 5.75 ± 0.05 Myr old (see also Cheng et al. 2005). The family consists of some 50 members, the largest being (832) Karin, an S-type asteroid (see, e.g., Nesvorný and Bottke, 2004).

Other important information required to understand the origin of an asteroid family includes the physical properties of the family members, notably their sizes, spectral signatures (and hence mineralogy), as well as their spin rate and sense of rotation. In particular, observations in the thermal IR, combined with knowledge of the absolute magnitude, H, and an appropriate thermal model (see e.g. Harris 1998) can provide information on albedos. Such observations are currently being carried out on 17 Karin family members using the Spitzer IR space telescope (Program # 20158, PI A.W. Harris). The observations reported here are part of the ground-based campaign organized to facilitate the data reduction and analysis of the Spitzer data. Improved H values and the knowledge of the lightcurve amplitude are necessary model parameters.

2. Observations

Observations were made at the cassegrain focus (f/9) of the 2-m Himalayan Chandra Telescope (HCT) on 25 and 26 November, 2005. The telescope is situated at a height of 4500 m above mean sea level on Mount Saraswati (Latitude 32d46m46s N and Longitude 78d57m51s E), Himalaya, and is remotely operated from the Indian Institute of Astrophysics, Bangalore via a dedicated satellite link.

This telescope is equipped with an optical CCD imager with a SITe ST-002 detector. The CCD has an imaging area of 2048 by 4096 pixels, each 15 μm in size, and it is thinned and back illuminated. The image scale is 0.17 arcsec/pixel. For our photometric measurements, this CCD was used in a 2k $\times$ 2k pixel mode. Relative photometry was performed for all our asteroid observations in the V band (550 μm).

We applied for five nights of observing time at the 2-m Hanle telescope in November 2005, close in time to the envisaged Spitzer observations. The observing period was chosen also because it provided good observing opportunities for several family asteroids, i.e. allowing all night coverage to ensure a long baseline for lightcurve studies. Since we were given only two nights (Nov. 25 and 26), we decided to limit the target list to two asteroids: (11728) Einer (for which rotational data have already been published by Yoshida et al. 2005) in order to improve the rotation period, and (93690) 2000 VE_{21}, for which no information has been published to date. The aspect data for these two asteroids are summarized in Table 1, where the various columns contain: (1) asteroid number and name/provisional designation, (2) mid-observing date and time, (3) ecliptic longitude (λ) and latitude (β), (4) solar phase angle α, (5) distance from the Sun (r) and (6) distance from the Earth (Δ), in astronomical units, (7) mean V magnitude, reduced to $r = \Delta = 1$ AU.

In order to obtain good time resolution, we decided to conduct observations only in one filter (V). For the determination of the absolute magnitude H, we observed two suitable standard stars which were selected from the Guide Star Photometric Catalogue II (GSPCII) (http://www-gsss.stsci.edu/Catalogs/GSPC/GSPC2/GSPC2.htm), and chosen to be located at a short angular distance from our targets and to have colours close to those of the Sun. The standards were observed at low airmasses. The relevant standard star data are listed in Table 2.

Table 1. Relevant data for the observed asteroids.

Asteroid	Date	UT	λ (J2000) (deg)	β	α (deg)	r (AU)	Δ (AU)	V(1,α) (mag)
(11728) Einer	2005 Nov 25	20.0	79.5	−2.2	5.4	2.91	1.95	14.1
	2005 Nov 26	20.0	79.3	−2.2	5.0	2.91	1.94	14.1
(93690) 2000 VE_{21}	2005 Nov 25	20.0	60.8	−3.6	1.6	2.77	1.78	15.7
	2005 Nov 26	20.0	60.6	−3.6	1.9	2.77	1.78	15.9

Table 2. Standard stars used.

designation	λ (J2000) (deg)	β	V (mag)	V-R (mag)
n414-aaae	63.0	−0.6	14.39	0.48
n417-aaeh	81.4	−4.4	14.97	0.46

Flatfields and bias frames were taken at the beginning and end of each observing night. The fields for the asteroids were selected carefully to ensure the availability of as many comparison stars as possible during the whole night.

Typical integration time for both asteroids were 240 seconds.

3. Data reduction and analysis

The synthetic aperture software package ASTPHOT, developed at the DLR Institute of Planetary Research in Berlin, was used to process the CCD frames obtained with the HCT instrument. For a more detailed description see, e.g., Mottola et al. (1995).

The photometric technique used was differential measurements against a series (8-10) of on-field comparison stars, which could be followed during the whole night. Finally, a calibration to the standard Johnson V system was obtained via the GSPCII standard stars. The random errors of the individual data points are estimated to be 0.01 - 0.02 mag for Einer, and 0.02 - 0.04 for 2000 VE_{21}, which was much fainter. The absolute error has been estimated to be of the order of 0.05 mag in both cases.

The resulting time series were processed with a Fourier analysis tool (Harris et al., 1989) for searching the rotation period that best fit the data.

The absolute magnitudes H were determined by extrapolating the mean reduced magnitudes V(1,α) to zero phase angle by using the H-G photometric model of Bowell et al. (1989). By doing so, we assumed G=0.15, which is an accepted value for asteroid surfaces. Because the observations of both asteroids were performed at small solar phase angles, the resulting H values should be relatively reliable.

4. Results and discussions

11728 Einer. We derive a best-fit rotation period $P = 12.92 \pm 0.16h$. Figure 1 shows the lightcurve composite folded using this period. The abscissa represents the rotational phase, and the ordinate gives the observed V-magnitude reduced to 1 AU from the Earth and from the Sun. Points beyond rotational phase 1.0 are repeated for clarity.

The period we determined differs significantly from the one published by Yoshida et al. (2005) ($P = 13.62 \pm 0.05h$). At the time of writing this difference remains resolved. Further observations and/or a full publication of the Yoshida et al. lightcurve data and observing circumstances are necessary to address this discrepancy in detail. Our absolute magnitude, $H = 13.70 \pm 0.05$, and the lightcurve amplitude, 0.19 mag, are comparable to those from previous measurements. The new H value is an improvement on the one published by the MPC (http://cfa-www.harvard.edu/iau/MPEph/MPEph.html) (14.2), which is based on astrometric measurements only and is therefore poorly determined.

93690 2000 $\mathbf{VE}_{21}$. Due to the small amplitude of the lightcurve, and the uneven distribution of the data points, no reliable rotation period could be determined. Using the mean value of the calibrated lightcurve, we calculated $H = 15.58 \pm 0.05$ (cf. H = 15.8 published by the MPC). The lightcurve amplitude is about 0.2 magnitude over the two nights, and the shape of the lightcurve suggests a rather long rotation period. More observations would be needed to reliably determine its actual value. The lightcurves for the two dates of observations are shown in Figures 2 and 3.

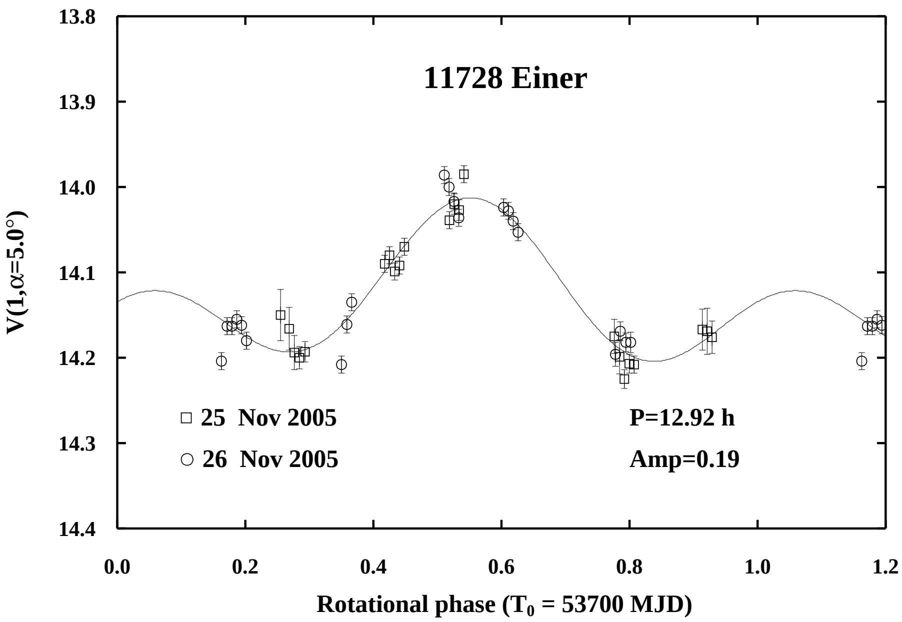

Figure 1. Composite lightcurve of (11728) Einer.

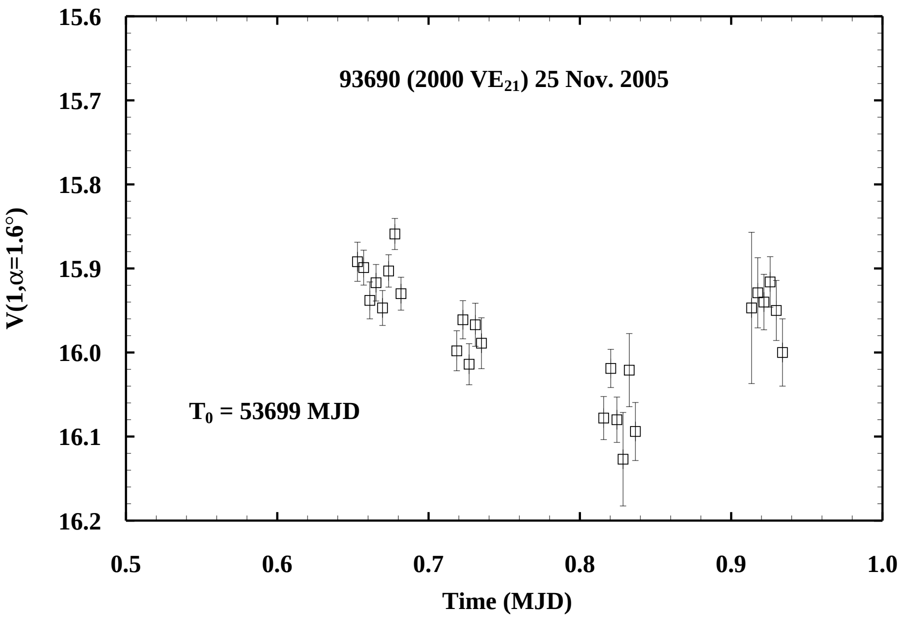

Figure 2. Lightcurve of (93690) 2000 VE_{21} from Nov. 25.

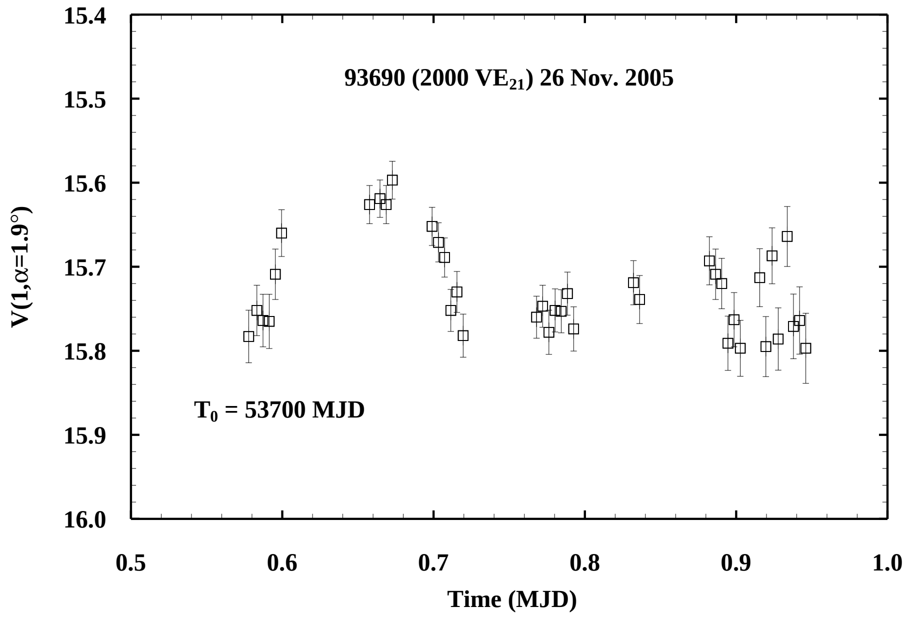

Figure 3. Lightcurve of (93690) 2000 VE_{21} from Nov. 26.

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