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A FLARE EVENT DETECTED IN THE ECLIPSING BINARY CM Dra

CM Dra is an eclipsing binary with the period of $1^{d}.26838965$ and the inclination angle of $89^{\circ}.82$ (Lacy 1977). It is a very interesting object by two facts. First, it has been currently known as a main-sequence eclipsing double-lined spectroscopic binary with the lowest mass ($0.23M_{\odot}$ and $0.21M_{\odot}$; Metcalfe *et al.* 1996). Therefore it offers an excellent opportunity to test the structure and evolution model of very low-mass stars (Metcalfe *et al.* 1996; Chabrier & Baraffe 1995). Second, a planetary occultation with a period about 735^{d} or a submultiple of it was reported in this eclipsing-binary system (Guinan 1996; Martin and Deeg 1996).

In this paper, we present the detection of a flare event from the BVI differential photometry, performing as a part of the TEP (Transits of Extrasolar Planets) international collaboration (Martin et al. 1996). Time-series CCD photometry of CM Dra has been carried out for eight nights from January 20 to March 5, 1997 (Table 1). The observations were made with a TEK1024 CCD camera attached to the 1.8m telescope at Bohyunsan Optical Astronomy Observatory (BOAO). The field of view on the CCD image is $5'.8 \times 5'.8$ at the f/8 Cassegrain focus of the telescope. The exposure times were 240 sec, 150 sec and 5 sec for B, V and I filters, respectively.

The preprocessing of CCD images including the overscan correction, the trimming of unreliable subsection, the bias correction and the flat field correction, was made with the IRAF/CCDRED package. We adopted simple aperture photometry to obtain instrumental magnitudes, using the IRAF/DAOPHOT package (Massey & Davis 1992) and applied the classical two-star differential photometry to get differential magnitudes. Two comparison stars ($V=14^{m}.2$, $B-V=1^{m}.1$ for C1; $V=14^{m}.9$, $B-V=0^{m}.6$ for C2, from our observation) near CM Dra were monitored to check the light variability of CM Dra (Figure 1). The detailed analysis of light variations (Figure 2) for CM Dra will be given in elsewhere (Kim *et al.* 1997).

Table 1. Observation Log

Obs. Date	Start H.J.D.	Obs. Time	Airmass	Phase	Seeing
Jan. 20	2450469.25	$3^{h}.0$	2.00∼1.24	0.394∼0.475	$3''.3$
29	478.25	3.5	1.80∼1.14	0.482∼0.597	2.2
Feb. 1	481.25	2.8	1.72∼1.18	0.849∼0.924	1.8
2	482.28	2.8	1.48∼1.12	0.663∼0.754	2.4
3	483.25	3.2	1.64∼1.13	0.430∼0.535	1.7
16	496.20	0.3	1.79∼1.68	0.635∼0.646	2.5
19	499.19	4.5	1.83∼1.09	0.991∼0.139	2.8
Mar. 5	513.12	6.0	2.17∼1.07	0.974∼0.171	1.8

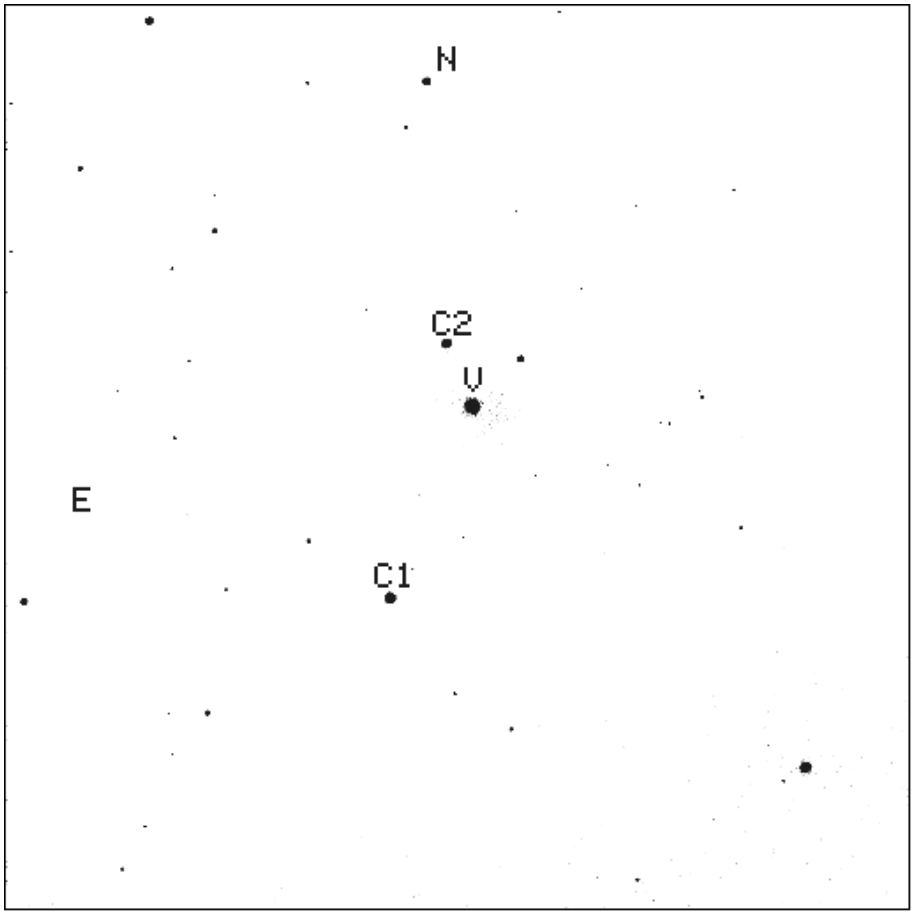

Figure 1. Finding chart of CM Dra. Two comparison stars are denoted as C1 and C2

Peculiar light variations of CM Dra were observed on February 2, 1997 (J.D.2450482.28), from phase 0.66 to 0.72. The brightness increased up to about $0^{m}.20$ in B and $0^{m}.06$ in V relative to the normal out-of-eclipse value. This is unlikely to be due to the atmospheric differential extinction because the differences in the airmass among three stars are negligible and their color differences, $\Delta(B-V)_{V-C1}=0^{m}.5$ and $\Delta(B-V)_{C2-C1}=-0^{m}.5$, are not so large. Considering the brightness change within short time scale of $\sim$1.8 hours and the strong amplitude dependence on colors, it might be a flare as commonly detected in the late-type dwarfs (dMe for CM Dra).

An ultraviolet flare of CM Dra was initially observed by Eggen & Sandage (1967) on June 13, 1966. Its brightness increased by $0^{m}.7$ in U and U$-$B color changed from $1^{m}.03$ to $0^{m}.36$ on short time scale ($\sim$1 min), during the increase of light after mid-eclipse. By carrying out the BVRI high-speed photometry and differential I photometry to detect flare events of CM Dra, Lacy (1977) found only a single flare on May 14, 1976. From this, he estimated the flare rate about less than 0.05 per hour, which is much too low in contrast to that of classical Pop. I flare stars with similar luminosity ($\geq$2 flares/hour; Lacy *et al.* 1976). He suggested that, biased on the abnormally low flare rate and the high space velocity of 163 km/sec, CM Dra might be an evolved system (Pop. II composition). Metcalfe *et al.* (1996) also detected a single flare event from the spectra of CM Dra. In six exposures started from J.D.2446255.666, the emission lines of the primary were observed to be very strong.

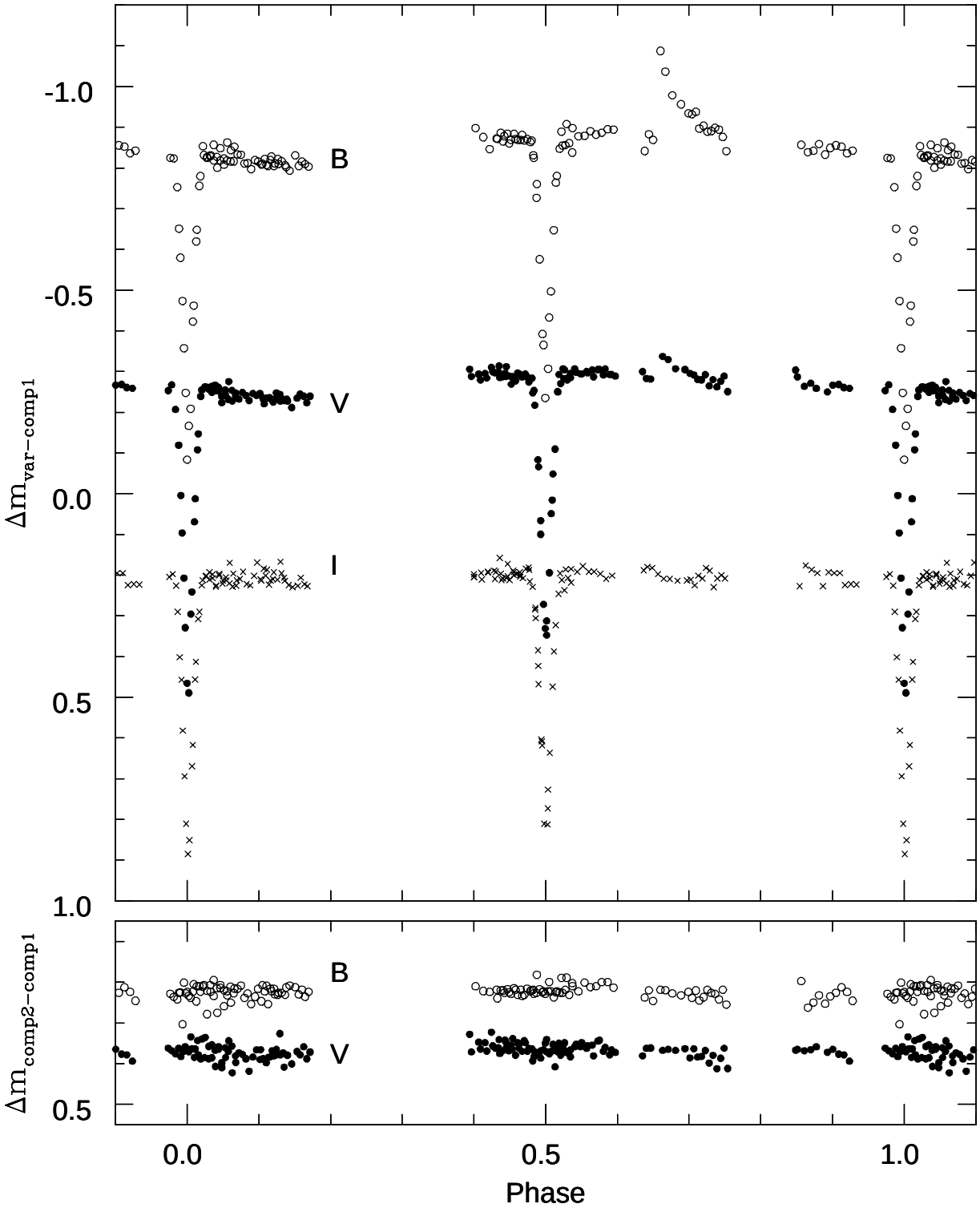

Figure 2. Light variations of CM Dra. A flare event was observed on Feb. 2, 1997, from phase 0.66 to 0.72. The brightness increased by $0\overset{m}{.}20$ in B and $0\overset{m}{.}06$ in V

Table 2. Flare events of CM Dra

Date(J.D.)	Phase	Duration	Characteristics	Flare rate	Ref
June 13, 1966	eclipse	$1^h.25$	$0^m.7$ increased in U		1
2442912.87	~0.93	1.0	$0^m.05$ increased in I	≤0.05/hour	2
2446255.66	~0.39	≥ 1.9	strong emission lines	~0.02/hour	3
2450482.28	~0.66	1.8	$0^m.20(0^m.06)$ increased in B(V)	≤0.04/hour	4

Ref. 1) Eggen & Sandage 1967, 2) Lacy 1977, 3) Metcalfe *et al.* 1996, 4) This paper

The characteristics of four flare events which have been detected in CM Dra are listed in Table 2. The ultraviolet flares of CM Dra might occur in any orbital phase. The brightness during a flare event abruptly increased and decreased on very short time scale of a few minutes (two points of B at the phase of 0.66 in Figure 2). Then its intensity decreased slowly, continuing for 1~2 hours. Flare rate estimated in this paper is ≤0.04 flares per hour, which is consistent with the other data. This low flare rate supports Lacy's (1977) suggestion that CM Dra might be a Population II star.

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