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BVRI OBSERVATIONS OF CZ ORIONIS IN OUTBURST

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CZ Ori is a very active dwarf nova (DN) that varies from $V = 16.6$ during quiescence to $V = 11.2$ in outburst (Ritter & Kolb 1998). It was discovered by Hoffmeister (1928) and first photometric observations were made by Nijland (1935) and later by Rosino (1941). The star has been monitored by the AAVSO, BAA and VSS, RASNZ ever since. The inter-outburst period is of 26 days (Bateson 1979). Williams (1983) made the first low dispersion spectrophotometric observations of CZ Ori: the spectrum show a typical quiescence DN spectrum with hydrogen and HeI in emissions. Szkody & Mattei (1984) analysed its long-term light curve and classified it as a U Gem star, with only normal outbursts. Szkody (1987) emphasized the narrow profile of the hydrogen lines as an indication of the small inclination of the system. In the same paper Szkody gives the colours of CZ Ori: $B - V = 0.33$ and $U - B = -1.12$, obtained when the system was at lowest level of brightness ($V = 16.77$); the UBV light curve of CZ Ori does not show any orbital modulation which might be ascribed to the presence of a hot spot in the disk.

Spectroscopic observations of the variable during an outburst were made by Spogli & Claudi (1994): they determined an orbital period of $0\overset{d}{.}2147$ studying radial velocities of the Hβ line of the Balmer series and the masses of the two component of the binary system: $M_1 = 0.94\ M_\odot$ and $M_2 = 0.56\ M_\odot$; these values are accepted and reported by Mennickent (1999). Ringwald et al. (1994) in the same year measured a value of the orbital period of $0\overset{d}{.}2189$ and they classified the secondary as a star of M2.5 $\pm$ 1.0 type. CZ Ori at quiescence was was never detected as an X-ray source during two satellite X-ray surveys (Cordova et al. 1981, Watson et al. 1987).

Table 1

	B	V	R_c	I_c
Maximum Outburst	12.43 ± 0.05	12.42 ± 0.05	12.36 ± 0.02	12.11 ± 0.02
Minimum of Light	16.8 ± 0.3	16.35 ± 0.15	15.70 ± 0.06	14.86 ± 0.04
Mean Values at Minimum	15.9 ± 0.5	15.7 ± 0.3	15.1 ± 0.3	14.4 ± 0.2
Outburst Amplitude	3.6	3.3	2.7	2.2
Decay Rates (mag/day)	0.37 ± 0.02	0.34 ± 0.02	0.31 ± 0.02	0.25 ± 0.02
	$B - V$	$V - R_c$	$V - I_c$	
Mean values at Maximum	0.01	0.18	0.46	
Mean Values at Minimum	0.17	0.52	1.29	

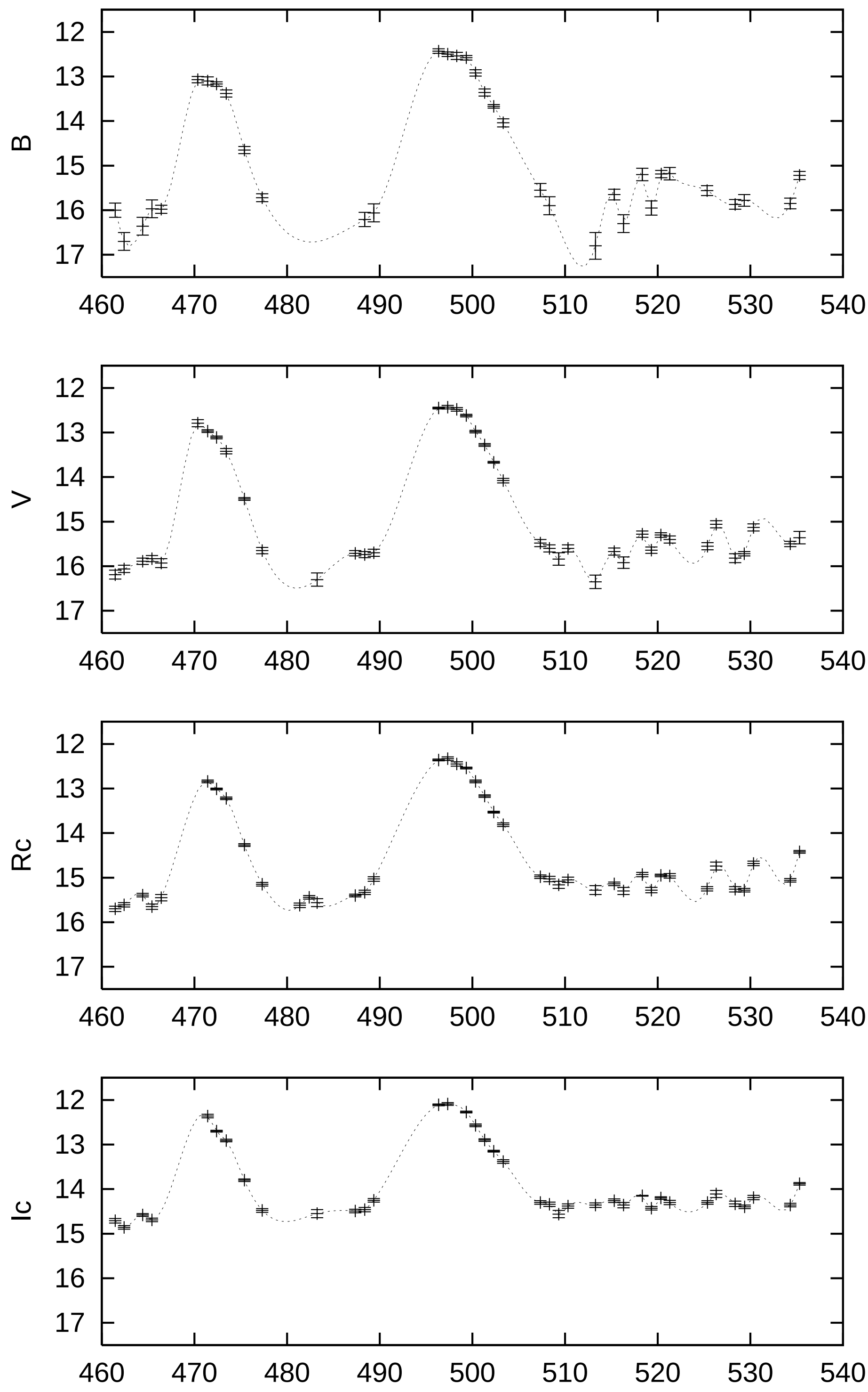

Figure 1. BVR_cI_c light curves of CZ Ori vs. the Julian Day starting from 2450000. Dotted lines connect consecutive points by natural cubic splines after rendering the data monotonic

Table 2: BVR_cI_c magnitudes of CZ Ori

J.D. (2450000 +)	B	V	R_c	I_c
461.4525	16.00 ± 0.16	16.19 ± 0.10	15.70 ± 0.06	14.71 ± 0.05
462.4084	16.70 ± 0.20	16.06 ± 0.08	15.61 ± 0.05	14.86 ± 0.04
464.4150	16.36 ± 0.20	15.89 ± 0.07	15.39 ± 0.04	14.58 ± 0.03
465.4187	15.97 ± 0.20	15.83 ± 0.07	15.65 ± 0.06	14.69 ± 0.04
466.4102	15.98 ± 0.09	15.93 ± 0.10	15.45 ± 0.07	
470.3591	13.07 ± 0.07	12.79 ± 0.08		
471.4247	13.11 ± 0.09	12.97 ± 0.03	12.84 ± 0.03	12.36 ± 0.04
472.3917	13.17 ± 0.05	13.11 ± 0.03	13.01 ± 0.02	12.70 ± 0.02
473.4352	13.38 ± 0.08	13.42 ± 0.06	13.22 ± 0.03	12.91 ± 0.03
475.3879	14.65 ± 0.08	14.49 ± 0.03	14.27 ± 0.03	13.80 ± 0.03
477.3190	15.72 ± 0.09	15.65 ± 0.07	15.15 ± 0.04	14.48 ± 0.04
481.3748			15.62 ± 0.05	
482.3879			15.44 ± 0.04	
483.2310		16.30 ± 0.15	15.56 ± 0.09	14.55 ± 0.09
487.3591		15.71 ± 0.06	15.40 ± 0.03	14.49 ± 0.04
488.3877	16.21 ± 0.16	15.74 ± 0.07	15.33 ± 0.05	14.46 ± 0.05
489.3534	16.06 ± 0.20	15.70 ± 0.08	15.03 ± 0.05	14.25 ± 0.04
496.3594	12.43 ± 0.05	12.45 ± 0.02	12.36 ± 0.02	12.11 ± 0.02
497.3412	12.50 ± 0.05	12.43 ± 0.04	12.33 ± 0.04	12.09 ± 0.03
498.3188	12.54 ± 0.08	12.48 ± 0.04	12.46 ± 0.05	
499.3427	12.58 ± 0.05	12.62 ± 0.03	12.54 ± 0.02	12.27 ± 0.02
500.3429	12.92 ± 0.07	12.98 ± 0.03	12.84 ± 0.03	12.57 ± 0.03
501.3289	13.36 ± 0.08	13.28 ± 0.03	13.17 ± 0.03	12.90 ± 0.03
502.3053	13.67 ± 0.04	13.67 ± 0.02	13.53 ± 0.02	13.15 ± 0.02
503.3295	14.04 ± 0.09	14.08 ± 0.05	13.81 ± 0.04	13.38 ± 0.04
507.3394	15.55 ± 0.15	15.48 ± 0.08	14.98 ± 0.04	14.30 ± 0.04
508.3113	15.90 ± 0.20	15.60 ± 0.08	15.03 ± 0.06	14.34 ± 0.05
509.3217		15.84 ± 0.14	15.16 ± 0.08	14.56 ± 0.08
510.3264		15.60 ± 0.08	15.05 ± 0.06	14.38 ± 0.05
513.2787	16.80 ± 0.30	16.35 ± 0.15	15.28 ± 0.13	14.36 ± 0.05
515.3085	15.65 ± 0.12	15.67 ± 0.08	15.14 ± 0.04	14.26 ± 0.04
516.3151	16.30 ± 0.20	15.92 ± 0.13	15.30 ± 0.08	14.36 ± 0.06
518.3369	15.20 ± 0.14	15.28 ± 0.07	14.93 ± 0.05	14.15 ± 0.01
519.3096	15.95 ± 0.16	15.64 ± 0.07	15.28 ± 0.06	14.43 ± 0.04
520.3347	15.18 ± 0.12	15.40 ± 0.05	14.91 ± 0.03	14.19 ± 0.03
520.3756	15.19 ± 0.11	15.20 ± 0.09	15.00 ± 0.05	14.22 ± 0.05
521.3016	15.18 ± 0.14	15.40 ± 0.08	14.96 ± 0.05	14.30 ± 0.05
525.3262	15.33 ± 0.13	15.66 ± 0.14	15.19 ± 0.06	14.22 ± 0.07
525.3785	15.79 ± 0.15	15.48 ± 0.08	15.31 ± 0.06	14.38 ± 0.04
526.3138		15.06 ± 0.08	14.74 ± 0.09	14.11 ± 0.08
528.3525	15.87 ± 0.11	15.82 ± 0.10	15.26 ± 0.06	14.33 ± 0.06
529.3319	15.48 ± 0.13	15.55 ± 0.05	15.03 ± 0.04	14.38 ± 0.03
529.3789	16.08 ± 0.15	15.90 ± 0.09	15.55 ± 0.07	14.42 ± 0.04
530.3485		15.13 ± 0.08	14.68 ± 0.05	14.19 ± 0.05
534.3127	15.85 ± 0.12	15.50 ± 0.06	15.06 ± 0.04	14.36 ± 0.04
535.3105	15.22 ± 0.09	15.36 ± 0.14	14.42 ± 0.03	13.88 ± 0.03

Here we present the BVR_cI_c photometric observations of CZ Ori during the period from 12 January 1997 to 27 April 1997 for a total of 43 days. The instruments used and the photometric techniques have been already described in Spogli et al. (1998). We used the calibration stars reported in Misselt (1996) with the numbers 2, 3, 4, 5, and 10. Moreover we calibrated these comparison stars with the I_c filter by observing, on photometric nights, several standard stars (Landolt 1992) having $B-V$ from -0.2 to 1.4, over a wide range of airmasses. The weighted means of the values obtained are:

$I_c(2) = 12.28 \pm 0.05$, $I_c(3) = 13.04 \pm 0.05$, $I_c(4) = 14.20 \pm 0.05$, $I_c(5) = 13.74 \pm 0.05$, and $I_c(10) = 14.40 \pm 0.08$.

We observed two outbursts with the maximum around JD 2450470 and JD 2450496, and we followed the decline. Unfortunately, in both cases we lacked the ascending phase. The light curves in the BVR_cI_c bands are presented in Figure 1, while Table 1 reports the main characteristics. All the photometric data are reported in Table 2. Our data show variations in the light curve during the minimum, more evident at shorter wavelengths, that require more investigation. The light curves show a linear decay with the average rates reported in Table 1.

BVR_cI_c observations of dwarf novae allow to evaluate the optical spectral behaviour and, therefore, they can be used as a test to compare theoretical models of accretion disk emission. In particular they can be used to verify the theoretical flux distribution of a stationary infinitely large accretion disk whose surface elements radiate as a black body ($F(\nu) \propto \nu^{1/3}$, see Warner 1995). The results presented here are part of a project devoted to gain multi-band light curves of a sample of DNe, with the goal of increasing the historical database and information on this class of variable sources which can help to constrain theoretical models. To study the behavior of the optical continuum of CZ Ori during the outburst, we converted the BVR_cI_c magnitudes in fluxes using the conversion factors reported by Bessell (1979). The extinction coefficient can be neglected (Bruch & Engel 1994). The spectral flux distribution of CZ Ori, during the two outbursts, is well described by a power law ($F(\nu) \propto \nu^{\alpha}$) with the slope α that varies from 0.2 to 0.4. The mean value in this phase is $\alpha = 0.31 \pm 0.05$: there is a substantial agreement with the predicted emission from an accretion disk in a stationary state.

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