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NEW EXTREME OUTBURST OF Z CMa

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Z CMa is an 0.1 arcsec pre-main sequence binary system (Koresko et al., 1991). It is a young stellar system consisting of a $16M_{\odot}$ B0 IIIe primary and a $\sim 3M_{\odot}$ secondary companion at an age of $\sim$0.3 Myr (Hartmann et al., 1989; Whitney et al., 1993; van den Ancker et al., 2004). The high resolution spectroscopy showed that Z CMa has the double-peaked emission line profiles whose shapes and widths are characteristic of FU Ori objects (Hartmann et al., 1989). The currently accepted interpretation for the FU Ori objects is that they are T Tau stars undergoing episodes of very rapid disk accretion. Indeed, under this interpretation, Z CMa has one of the highest accretion rates, $M_{acc} \simeq 10^{-4} M_{\odot}\ yr^{-1}$, observed in FU Ori systems (Hartmann and Kenyon, 1996).

On large scales, this system displays a collimated outflow (Cohen and Bieging, 1986; Poetzel et al., 1989) and has a roughly 400 AU disk-like structure (Malbet et al., 1993). The major axis of this disk-like structure is perpendicular to the large-scale bipolar jet. Recently, interferometric observations of both components have been obtained, probing their environment on AU scales (Millan-Gabet et al., 2006). Both components have been spatially resolved by these observations, but detailed analysis has revealed that both components are more complex than previously thought.

The photometric variations of the system have been monitored for 21 years (1983-2004) at Mt. Maidanak (Uzbekistan). The mean magnitude of the system has been continuously decreasing from 1983 to 1997 (from V $9\overset{\mathrm{m}}{.}3$ to V $10\overset{\mathrm{m}}{.}4$) and then remained nearly constant till a short duration (6 month) outburst in 1999/2000 when it has increased up to V $9\overset{\mathrm{m}}{.}5$ (see Figure 1 in van den Ancker et al., 2004). Based on high resolution spectroscopy, this outburst was identified as resulting from a large scale accretion instability in the circumstellar disk of the massive primary. Our last Mt. Maidanak observations of Z CMa in 2004 have shown that the average brightness of this system was $9\overset{\mathrm{m}}{.}94$ in V band.

We have decided to continue some patrol $UBVR$ observations of this star at Crimean Astrophysical Observatory (CrAO) in Ukraine since 2008. In September-November 2008 we have discovered that the Z CMa is again exhibiting an extreme outburst with an amplitude more than $1\overset{\mathrm{m}}{.}7$–$1\overset{\mathrm{m}}{.}9$, i.e., larger than any photometric variations recorded in the last 25 years. The statistical and photometric properties of the long-term light curve taken at Mt. Maidanak and at CrAO are presented in Table 1.

On November, 19th 2008 we have spread the information about this extreme outburst to all interested researchers and have suggested to make some simultaneous photometric, spectroscopic and interferometric observations of this star. Such coordinated observations took place within December 2008 - January 2009. We report here multi-color photometric observations of Z CMa taken during this unprecedented outburst state (see Table 2).

Table 1. Statistical properties of Z CMa light curve. Columns are: Year - observation season, N_{obs} - number of observations, $\overline{V}$ - mean magnitude in V, σ_V - standard deviation in V, V_{max} - maximum brightness in V, ΔV - photometric amplitude in V, $\overline{U-B}$, $\overline{B-V}$, $\overline{V-R}$ - mean color index in $U-B$, $B-V$, and $V-R$ accordingly.

Year	N_{obs}	$\overline{V}$	σ_V	V_{max}	ΔV	$\overline{U-B}$	$\overline{B-V}$	$\overline{V-R}$
1983	11	9.301	0.043	9.237	0.124	0.678	1.233	1.200
1984	10	9.337	0.046	9.243	0.140	0.672	1.236	1.218
1985	22	9.110	0.115	8.920	0.330	0.374	1.177	1.228
1986	9	9.027	0.209	8.745	0.533	0.403	1.136	1.182
1987	17	9.540	0.023	9.504	0.087	0.538	1.270	1.242
1988	35	9.551	0.040	9.492	0.148	0.752	1.295	1.197
1989	40	9.631	0.054	9.492	0.275	0.749	1.330	1.206
1990	32	9.592	0.024	9.542	0.102	0.692	1.321	1.221
1991	24	9.556	0.081	9.447	0.304	0.496	1.258	1.257
1992	21	10.055	0.018	10.023	0.063	0.797	1.391	1.232
1994	10	9.979	0.011	9.964	0.033	0.495	1.317	1.318
1995	23	10.169	0.039	10.031	0.190	0.608	1.348	1.300
1996	21	10.231	0.020	10.204	0.069	0.370	1.264	1.288
1997	19	10.412	0.028	10.309	0.127	0.421	1.277	1.337
1998	17	10.337	0.014	10.305	0.049	0.258	1.130	1.322
1999	23	9.491	0.182	9.224	0.676	0.468	1.044	1.207
2000	10	9.655	0.393	9.299	0.943	0.233	0.969	0.957
2001	15	10.081	0.075	9.961	0.224	0.319	1.088	1.251
2002	7	10.100	0.030	10.060	0.087	−0.055	0.913	1.291
2003	5	10.333	0.029	10.307	0.076	0.190	1.054	1.333
2004	11	9.940	0.023	9.906	0.073	−0.045	0.959	1.357
2008	10	8.662	0.215	8.408	0.633	0.034	0.804	0.896
2009	8	8.432	0.043	8.397	0.098	0.005	0.750	0.821

Table 2. Multi-color photometric observations of Z CMa at CrAO

Date	JDH2400000+	V_{mag}	$U-B$	$B-V$	$V-R$
30-Sep-2008	54740.6353	8.806	0.104	0.866	0.939
01-Oct-2008	54741.6449	8.786	0.139	0.833	0.924
23-Oct-2008	54763.6639	8.849	0.060	0.821	0.907
30-Oct-2008	54770.5778	8.888	0.077	0.834	0.898
07-Nov-2008	54778.6044	8.930	0.042	0.862	0.927
01-Dec-2008	54802.6248	9.041	0.051	0.868	0.982
12-Dec-2008	54813.5285	8.581	−0.080	0.761	0.879
12-Dec-2008	54813.5385	8.583	−0.038	0.772	0.873
12-Dec-2008	54813.5480	8.587		0.778	0.874
30-Dec-2008	54831.4622	8.434		0.816	0.853
21-Jan-2009	54853.3282	8.408	0.000	0.774	0.896
21-Jan-2009	54853.3414	8.425	0.004	0.766	0.882
05-Feb-2009	54868.2754	8.468	0.025	0.752	0.854
05-Feb-2009	54868.2809	8.476	0.028	0.751	0.861
04-Mar-2009	54895.2343	8.425	0.005	0.747	0.843
04-Mar-2009	54895.2463	8.412	0.006	0.743	0.840
21-Mar-2009	54912.2527	8.397		0.746	0.790
24-Mar-2009	54915.2456	8.495		0.763	0.812

It is visible from Table 1 that in the end of 2008 the mean magnitude of the system was V 8$^{\rm m}$.7, and in the beginning of 2009 it has achieved a value of V 8$^{\rm m}$.4. As the number of our multi-color data points are not numerous enough for the analysis of photometric behaviour of this star, we used all V-band data from the All Sky Automated Survey (ASAS) catalogue (see for example Pojmanski, 2002). The optical V light curve of Z CMa spanning the period 1998-2009 is shown in the top panel of Figure 1. We conclude from this Figure 1 that the new outburst (2008/2009) is really the brightest and longest lived within the last ten years. The duration of the new outburst exceeds 430 days (see bottom panel of Figure 1). It should be noted that the current outburst (2008/2009) and an optical light curve for the last seven years was published first by Stelzer et al. (2009). They used the visual photometry from the American Association of Variable Star Observers (AAVSO) and a few photoelectric CCD observations obtained by Czech observers. We tried to use the AAVSO data in our analysis too. But we have ascertained that these visual data have low precision and are suitable to check variations of an average level of light. However, the overall structure of the long-term light curve is well visible in Figure 1 of Stelzer et al. (2009) and in good conformity with our light curve.

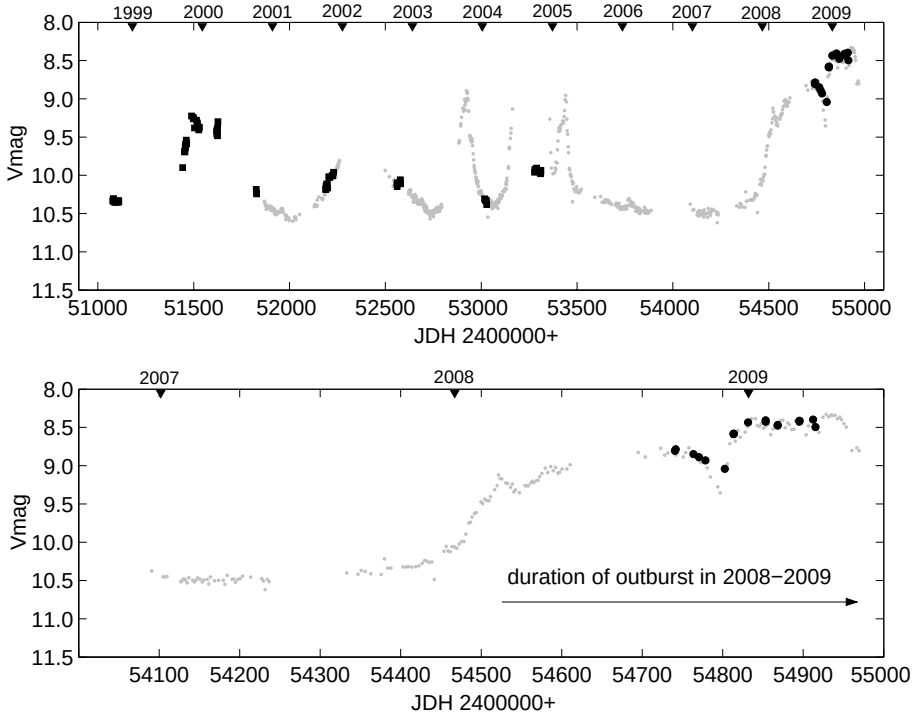

Figure 1. Optical V light curve of Z CMa spanning the period 1998-2009 (top panel) and new outburst (bottom panel). Data from the All Sky Automated Survey (ASAS) are indicated by the grey circles, data from Maidanak Observatory by black squares, and our new data points obtained at CrAO are indicated by the black circles.

Besides, the ASAS data show at least three more short-term outbursts during 2003-2006. The amplitudes of these outbursts are comparable or exceed the amplitude of the well studied 1999/2000 outburst. Unfortunately, we cannot tell anything about the color changes during these short-term outbursts because the ASAS data comprise only the V-band. Nevertheless, we can compare the color behaviour of two outbursts (1999/2000 and 2008/2009) on our multi-color observations at Maidanak and CrAO (see Figure 2).

Multi-color photometry indicates that the system is currently brighter and bluer (2008/2009 outburst) than it has ever been in the past (1999/2000 outburst). Besides, both outbursts show an uniform dependence on the color-magnitude and the color-color diagrams. It specifies the same mechanism of the photometric variability during these two outbursts. At the same time we see that the photometric variability during a quiet state (outside of outbursts) shows another dependence. It is visible especially clearly on the V, $U-B$ and V, $B-V$ diagrams. This may not be surprising, since we are probably observing the result of two independently varying sources, a FUor secondary component which usually dominates the visual continuum and a Be-type primary star in a large dust cocoon, which is dominating the near- and far-infrared part of the spectrum.

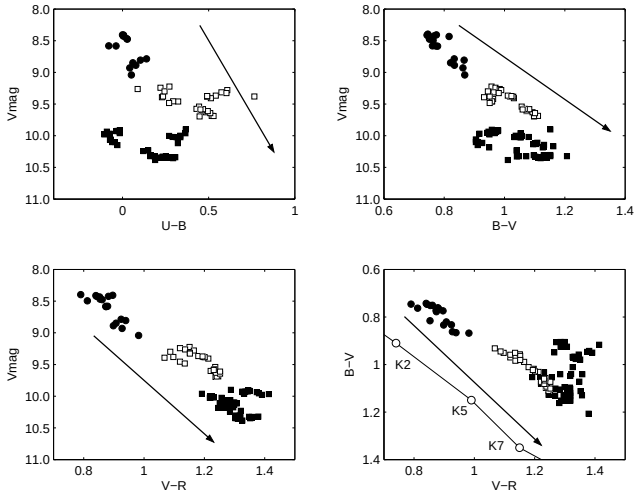

Figure 2. Optical color-magnitude and color-color diagrams of Z CMa using photometric data from the period 1998-2009. Data from the 1999/2000 outburst are indicated by the open squares, data from the 2008/2009 outburst by black circles, and other data outside of outbursts are indicated by the black squares. The arrows indicate the direction of interstellar reddening.

We expect that the recent IR photometric, high resolution spectroscopic and VLTI interferometric observations taken during the integrated observational campaign in 2008-2009 will allow us to understand the physics of this phenomenon more deeply.

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