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BVR_CI_C Photometric Evolution and Flickering during the 2010 Outburst of the Recurrent Nova U Scorpii

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Abstract: CCD BVR_CI_C photometric observations of the 2010 outburst of the recurrent nova U Scorpii are presented. The light-curve has a smooth development characterized by $t_2(V)=1.8$ and $t_3(V)=4.1$ days, resembling that of previous outbursts. The plateau phase in 2010 has been brighter, lasting shorter and beginning earlier than in the 1999 outburst. Flickering, with an amplitude twice large in I_C than in B band, was absent on day +4.8 and +15.7, and present on day +11.8, with a time scale of about half an hour.

The 2010 outburst of the recurrent nova U Scorpii was discovered by B.G. Harris (New Smyrna Beach, FL, USA) on Jan. 28.4385 UT, when the star was measured at $V=8.05$ (cf Schaefer, 2010). On Jan 27.63 UT, i.e. 0.80 days earlier, the nova was still at quiescence brightness ($V \geq 16.5$ mag, Linnolt, 2010).

This is the 10th recorded outburst of U Scorpii. Previous ones occurred on 1863, 1906, 1917, 1936, 1945, 1969, 1979, 1987 and 1999 according to the recent summary by Schaefer (2009). The last outburst has been the best observed one, with detailed reports being provided by Munari U. et al. (1999), Kiyota (1999), Lépine et al. (1999), Anupama and Dewangan (2000), Hachisu et al. (2000), Evans et al. (2001) and Iijima (2002).

We obtained accurate $BVR_{CI}C$ of U Sco with a 0.30-m Meade RCX-400 f/8 Schmidt-Cassegrain telescope equipped with a SBIG ST-9 CCD camera. The photometry was accurately corrected for color equations using nightly calibration on Landolt (1992) standard stars. The data are presented in Table 1, and plotted in Figure 1. The external errors (always less than 0.02 mag) do not exceed the dimension of the symbols in Figure 1.

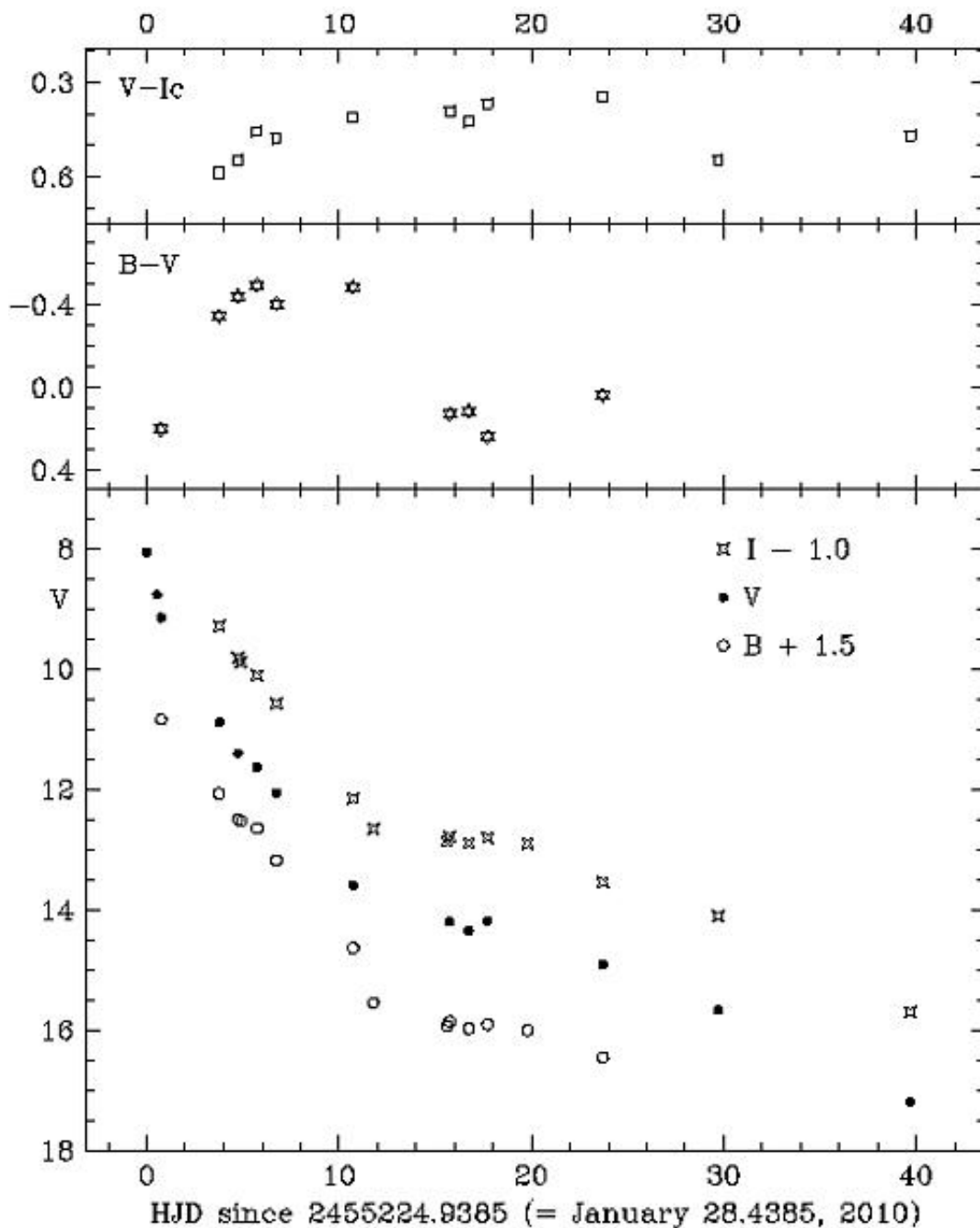


Fig. 5930-f1. $BVR_{CI}C$ photometric evolution of the 2010 outburst of the recurrent nova U Scorpii according to our observations listed in Table 1. The point at $t=0.0$ days, $V=8.05$ is taken from IAUC 9111, that at $t=0.54$ days, $V=8.76$ from ATel 2412.

In Figure 1 the time is counted from the discovery of U Sco in outburst on Jan. 28.4385 UT ($t=0.00$ days), that we assume as the time of actual maximum, there being no earlier observations of U Sco or reporting it brighter than $V=8.05$. The light curve in Figure 1 is characterized by a smooth decline, similar to that of previous outbursts (cf Munari et al. 1999; Kiyota 1999). The decline times (± 0.1 days) are: $t_2^V=1.8$ $t_3^V=4.1$ days that are significantly slower than $t_2=1.2$, $t_3=2.6$ days reported by Schaefer (2009) as

typical values for previous outbursts, and instead much closer to the $t_2=2.2$, $t_3=4.3$ days derived by Munari et al. (1999) for the 1999 outburst. The light-curve in Figure 1 exhibits a plateau phase extending from day +12 to day +20, during which the mean colors are $\langle V \rangle = 14.25$ $\langle B-V \rangle = +0.16$ $\langle V-R_C \rangle = +0.35$ $\langle V-I_C \rangle = +0.41$. This phase corresponds to the white dwarf still burning hydrogen in the envelope and the ejecta being transparent to soft X-rays. In fact, on day +12, Schlegel et al. (2010) found U Sco to have become a super-soft X-ray source with a brightness 100 times larger than a previous observation on day +8. Osborne et al. (2010) found U Sco still in super-soft conditions at day +17.5. A plateau was observed also during the 1999 outburst (Kiyota 1999, and Hachisu et al. 2000), but at a fainter mean magnitude ($\langle V \rangle = 14.75$), lasting slightly longer (11 days) and starting appreciably later, on day +17.

With a 0.40-m f/8 Ritchey-Chrétien telescope located on Monte Baldo (Verona, Italy), and equipped with a Finger Lake Instruments ML1001E CCD camera, we carried out three runs in B and I_C filters looking for short time variations in U Sco. The results are presented in Figure 2.

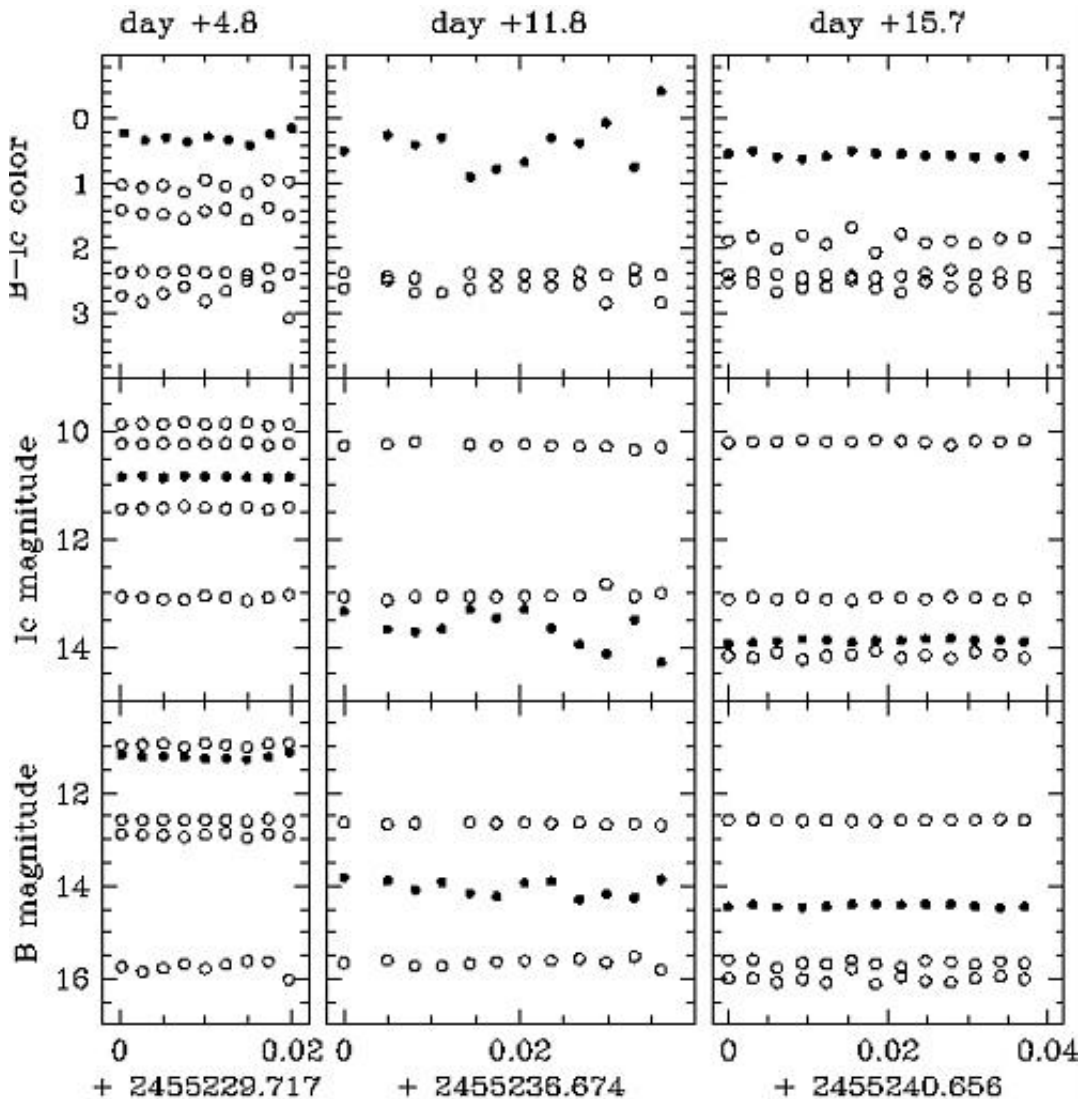


Fig. 5930-f2. Results of searches for flickering carried out on days +4.8, +11.8 and +15.7 in the B and I_C bands. The dots represent measurements of U Sco, the circles those of nearby field stars to monitor photometric stability.

Table 1. Our BVR_CI_C of U Scorpii

HJD	date HUT	V	B-V
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V-R_C V-I_C R_C-I_C

225.6933	2010	01	29.19	9.140	0.201				
228.7090	2010	02	01.21	10.888	-0.347	0.831	0.586	-0.300	
229.6861	2010	02	02.19	11.401	-0.441	0.751	0.546	-0.217	
230.6817	2010	02	03.18	11.632	-0.495	0.582	0.455	-0.239	
231.6799	2010	02	04.18	12.059	-0.405	0.572	0.477	-0.146	
235.6682	2010	02	08.17	13.592	-0.487	0.365	0.410	0.022	
240.6921	2010	02	13.19	14.207	0.128	0.347	0.391	0.038	
241.6912	2010	02	14.19	14.349	0.113		0.423		
242.6575	2010	02	15.16	14.184	0.236	0.286	0.366	0.078	
248.6599	2010	02	21.16	14.912	0.035	0.275	0.344	0.062	
254.6492	2010	02	27.15	15.674		0.227	0.545	0.317	
264.6344	2010	03	09.13	17.197			0.467		

No flickering was detected on day +4.8, while the short term variability was clearly present on day +11.8 (at the beginning of the plateau phase). Worters et al. (2010) reported that the flickering became visible on day +8, and they attributed it to an accretion disk that had already been re-established and was visible through optically thin ejecta. Our last observing run on day +15.7 (and additional three scattered points around day +19.8), at the center of the plateau phase, did not however show any short term variability, which cast doubts on the Worters et al. interpretation in terms of re-established accretion. The flickering we observed had a characteristic time scale of ~half an hour, and a larger amplitude in I_C ($\Delta m=1.0$ mag) than in B band ($\Delta m=0.5$ mag).

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