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BVRI PHOTOMETRY OF DWARF NOVAE

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Dwarf Novae (DNe) are a subclass of cataclysmic variable stars, which are close binary systems in which matter transferred from a Roche-lobe filling secondary star is accreted by a primary white dwarf (Warner, 1995). In dwarf novae accretion proceeds through a disk which is the site of more or less regular outbursts. The recurrence time of these 2-6 mag outbursts can range from 10 days to several years. Dwarf novae can be divided into three subclasses: U Gem-type stars which have the most regular outburst cycles, SU UMa-type stars showing both short and very long outbursts (super-outbursts), and Z Cam stars. The last group is characterized by a "standstill" phenomenon: the decline from the outburst maximum is interrupted and the luminosity of the system settles to a value of ~ 0.7 mag lower than the peak luminosity. Such standstill may last from ten days to years and, after that phase, the system luminosity declines to the usual quiescent state.

In this brief paper we present B, V, R_c, I_c photometric observations of a sample of dwarf novae made in the years 1998-2002. We are mainly interested to obtain multi-color data of a large sample of DNe during all the outburst-cycle, a work that requires large availability of well-equipped small telescopes and generally good weather conditions for many days. Here we present the sporadic observations that do not cover the outbursts cycle because were obtained during the stand-still, or interrupted for persisting bad weather conditions. However, these informations are useful for a historical database of this class of sources, and because for many of them there are no optical color indices reported in the literature.

The photometric data were mainly obtained with the 0.72 m telescope of the Teramo Astronomical Observatory, and the 0.40 m Automatic Imaging Telescope of the Perugia University Observatory (Tosti et al., 1996). The instruments used and the photometric techniques have already been described in Spogli et al. (1998, 2000). We have also used the 0.24 m Schmidt-Cassegrain f/6.3 telescope equipped with an HISIS 23 CCD camera (Kodak 401-E, 768×512 pixels), and the 0.33 m Newtonian f/4.5 telescope equipped with an MX-916 CCD camera (768×512 pixels), of the "Subasio" astronomical station. Both the telescopes are endowed with a standard R_c Cousins broad-band filter. A comparison with results obtained with the other telescopes shows no relevant systematic difference within the typical standard deviation of each instrument. The data reported in Table 1 are obtained in differential photometry using the calibration stars reported in Misselt

(1996). 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 airmass.

The selected dwarf novae have been observed in different phases of luminosity: a few of them were in outburst, others at minimum or in stand-still. For the dwarf novae that were in outburst at the time of the observations, we calculated the spectral index α (Table 2) using the same procedure described in Spogli et al. (1998) and neglecting interstellar reddening.

Table 1: BVR_cI_c magnitudes of some Dwarf Novae

Name	Type*	Date UT	JD (245+)	B	V	R_c	I_c
AR And	ug	98/08/28	1053.538		16.49±0.02	16.25±0.01	15.44±0.02
		98/08/31	1056.555	16.89±0.04	16.51±0.02	16.05±0.01	15.34±0.03
		98/09/01	1057.590	16.67±0.03	16.38±0.02	15.96±0.02	15.30±0.02
		98/09/02	1058.598	16.85±0.04	16.56±0.02	16.05±0.02	15.38±0.03
		98/09/03	1059.574	16.71±0.04	16.35±0.02	15.92±0.03	15.20±0.02
		98/09/03	1060.429	16.95±0.04	16.49±0.02	16.05±0.02	15.22±0.04
		98/09/06	1063.446		16.76±0.02		15.56±0.02
		98/09/10	1067.431	17.23±0.03	16.89±0.02	16.32±0.02	15.72±0.04
BV And	ug:	98/08/28	1053.501		18.1±0.2	17.9±0.2	17.7±0.2
DX And	ug	98/08/27	1053.489		15.01±0.02	14.34±0.03	13.87±0.05
		98/08/31	1057.402	15.55±0.02	14.76±0.02	14.11±0.02	13.68±0.04
		98/09/01	1058.397	15.52±0.02	14.68±0.02	14.17±0.03	13.72±0.03
		98/09/02	1059.457	15.26±0.02	14.58±0.04	13.99±0.06	13.61±0.05
FO And	ugSU	02/11/22	2601.429			14.81±0.05	
FS And	ugSU:	02/12/29	2638.281			16.8±0.1	
RX And	ugz	98/08/27	1052.547	11.87±0.02	11.77±0.02	11.63±0.02	11.38±0.02
		98/08/28	1053.563	11.88±0.03	11.78±0.02	11.65±0.02	11.39±0.02
		98/08/31	1056.537	11.99±0.02	11.85±0.02	11.66±0.02	11.43±0.02
		98/08/31	1056.611	12.03±0.02	11.84±0.02	11.67±0.02	11.42±0.02
		98/09/01	1057.542	11.90±0.03	11.77±0.03	11.62±0.02	11.34±0.02
		98/09/01	1057.621	11.96±0.02	11.82±0.02	11.67±0.02	11.41±0.02
		98/09/02	1058.523	11.97±0.02	11.84±0.02	11.62±0.03	11.42±0.02
		98/09/02	1058.618	12.03±0.02	11.78±0.02	11.65±0.03	11.38±0.02
		98/09/03	1059.527	12.08±0.02	11.87±0.02	11.67±0.02	11.45±0.02
		98/09/03	1059.528	12.06±0.02	11.82±0.02	11.70±0.02	11.46±0.02
		98/09/03	1059.621	12.04±0.02	11.90±0.02	11.73±0.02	11.42±0.02
		98/09/03	1060.411	12.14±0.04	11.95±0.02	11.76±0.03	11.48±0.02
		98/09/10	1067.379	12.17±0.03	12.02±0.02	11.86±0.02	11.53±0.02
		02/11/15	2594.405			13.47±0.05	
		02/11/22	2601.413			11.03±0.03	
		02/12/29	2638.237			13.98±0.03	
HT Cas	ugSU	98/09/02	1058.597	16.4±0.2	16.1±0.1	15.76±0.05	
V516 Cyg	ugSS	00/08/18	1775.463	14.43±0.08	14.12±0.08	13.93±0.08	
		00/08/23	1780.411		16.2±0.1	15.94±0.05	
		00/08/25	1782.328		16.5±0.1	16.2±0.1	15.75±0.03
		00/08/29	1786.323	14.6±0.1	14.33±0.05	14.21±0.08	14.03±0.03
V516 Cyg	ugSS	00/08/29	1786.491	14.51±0.08	14.19±0.05	14.05±0.08	13.92±0.03
		00/09/08	1796.428	15.43±0.08	15.21±0.05	14.93±0.05	14.68±0.04
		00/09/09	1797.452	14.12±0.07	14.05±0.05	14.01±0.08	13.89±0.03
		00/09/26	1814.493	16.9±0.1	16.3±0.1	16.1±0.1	15.60±0.05
V632 Cyg	ugSS	98/08/26	1052.398			16.9±0.2	
		98/09/01	1057.529		18.1±0.3	17.1±0.2	

*) from Downes et al. (2001)

Table 1: BVR_cI_c magnitudes of some Dwarf Novae (continues)

Name	Type*	Date UT	JD (245+)	B	V	R_c	I_c
V1028 Cyg	ugSU	98/08/26	1052.435			16.3±0.1	
V1032 Cyg	ug	98/08/26	1052.440			16.1±0.1	
V1052 Cyg	ugSS	98/08/26	1052.444			15.38±0.05	
V1060 Cyg	ugSS	98/08/26	1052.464			16.1±0.1	
V1316 Cyg	ugSU	98/09/01	1058.454		17.8±0.3	17.4±0.2	17.3±0.2
V1377 Cyg	ug:	98/08/26	1052.462			15.51±0.05	
MN Lac	ugz	98/08/30	1056.493		15.69±0.07	14.99±0.05	14.59±0.04
CN Ori	ugz	02/02/11	2317.327	12.68±0.07	12.77±0.05	12.68±0.04	12.41±0.04
		02/02/22	2328.329	15.92±0.09	15.31±0.05	14.91±0.05	14.34±0.05
		02/03/04	2338.326	13.48±0.09	12.99±0.05	12.85±0.04	12.55±0.04
		02/03/10	2344.361	17.4±0.2	16.1±0.1	15.44±0.05	14.59±0.05
CZ Ori	ug	98/03/10	0883.357		16.3±0.1	15.85±0.05	14.84±0.04
		98/03/14	0887.381			14.50±0.05	14.08±0.04
		98/03/16	0889.317	12.81±0.06	12.67±0.05	12.62±0.04	12.39±0.04
		98/03/17	0890.312	12.67±0.07	12.82±0.05	12.64±0.04	12.43±0.04
		98/03/18	0891.313	12.89±0.07	13.03±0.05	12.90±0.04	12.65±0.04
		98/03/27	0900.313	16.8±0.1	16.35±0.08	15.74±0.05	14.89±0.04
		98/03/29	0902.317		16.1±0.1	15.72±0.05	14.87±0.04
		99/03/01	1239.393		14.41±0.05	13.99±0.05	13.69±0.04
		99/03/03	1241.387			15.23±0.05	14.71±0.04
		99/03/10	1248.375			16.00±0.08	15.01±0.05
		99/03/11	1249.361		16.36±0.05	16.03±0.05	15.06±0.04
IP Peg	ug	98/08/28	1053.517	16.5±0.1	15.80±0.04	15.24±0.05	
RU Peg	ugSS	98/09/03	1059.501	12.53±0.02	12.11±0.02	11.82±0.02	
FO Per	ug	98/08/31	1056.628	14.01±0.05	13.77±0.05	13.57±0.05	13.29±0.04
		98/09/01	1057.562	14.11±0.05	13.86±0.05	13.57±0.05	13.36±0.04
		98/09/02	1058.637	14.42±0.03	14.19±0.03	13.91±0.03	13.62±0.03
		98/09/03	1059.614	14.98±0.04	14.81±0.02	14.57±0.04	14.24±0.03
		02/02/11	2317.309	15.06±0.06	15.03±0.03	14.82±0.05	14.49±0.03
		02/02/22	2328.306	13.92±0.04	13.75±0.03	13.62±0.05	
		02/02/24	2330.312	14.85±0.05	14.42±0.05	14.37±0.05	
		02/03/10	2344.311		14.03±0.03	13.86±0.05	13.57±0.04
		02/03/11	2345.291	14.19±0.03	14.03±0.03	13.86±0.05	13.58±0.04
		02/03/13	2347.286		16.2±0.2	15.79±0.05	15.43±0.06
		02/03/23	2357.297		17.3±0.3	17.0±0.2	16.2±0.1
		02/03/29	2363.293		13.61±0.03	13.38±0.04	13.20±0.05
		02/03/30	2364.294		13.65±0.05	13.53±0.05	13.21±0.05
KT Per	ugz	00/08/26	1782.515	12.84±0.05	12.75±0.05		
		00/08/29	1786.499	16.1±0.1	15.57±0.05	15.18±0.05	
		00/08/30	1786.560	15.89±0.05	15.47±0.05		
		00/09/09	1796.655	15.82±0.07	15.56±0.05	14.99±0.05	14.35±0.05
		00/09/11	1799.464		15.53±0.05	15.05±0.05	14.21±0.05
		00/09/23	1810.511	16.30±0.08	15.86±0.06	15.37±0.05	14.37±0.05
		00/09/27	1814.513	12.85±0.06	12.71±0.05	12.52±0.04	12.33±0.04
		00/09/27	1814.573	12.78±0.07	12.69±0.05	12.53±0.04	12.35±0.04
		00/09/28	1815.535	12.69±0.07	12.53±0.05	12.38±0.04	12.17±0.04
		00/10/12	1830.342				14.21±0.05
		00/10/28	1846.323				14.48±0.07
TU Tri	ug	98/09/03	1059.586				18.3±0.2
TX Tri	ugSS	98/09/03	1059.583				16.5±0.1
TW Tri	ugz	98/09/03	1059.603			16.7±0.1	16.4±0.1
SW Vul	ug	98/08/31	1056.509	19.1±0.3	18.4±0.3	17.9±0.2	17.7±0.2
VW Vul	ugSU	98/08/30	1056.413		18.1±0.2	17.7±0.2	16.4±0.1

*) from Downes et al. (2001)

Table 2: Mean spectral slope ($F(\nu) \propto \nu^{\alpha}$) of some DNe

Name	Type*	Magnitude Range*	Obs. Values	α
RX And	ugz	10.9 v – 12.6 v	V $\simeq$ 11.8	0.2 $\pm$0.1
V516 Cyg	ugSS	13.8 p – 16.8 p	V $\simeq$ 14.1	0.3 $\pm$0.2
CN Ori	ugz	11.9 v – 16.3 v	V $\simeq$ 12.8	0.5 $\pm$0.2
CZ Ori	ug	11.2 V – 17.0 V	V $\simeq$ 12.7	0.4 $\pm$0.2
FO Per	ug	11.8 v – 16.2 p	V $\simeq$ 13.8	0.0 $\pm$0.2
KT Per	ugz	10.6 V – 16.1 V	V $\simeq$ 12.6	0.3 $\pm$0.1

*) from Downes et al. (2001)

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