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Unidentified Extremely Red Objects in the field of some Dwarf Novae

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Abstract. We present the photometric data of unknown objects discovered in the field of some Dwarf Novae. These objects show extremely red colours: $V - I_c > 4$ and $R_c - H > 5$, therefore can be formally classified as EROs. Here we report preliminary results and a brief discussion on their nature.

Key words. Cataclysmic Variables: Dwarf Novae – Extremely Red Objects

1. BVR_cI_c observations of Dwarf Novae

Dwarf Novae are a subclass of Cataclysmic Variables which show a large excursion in their brightness (typically 2–5 magnitudes in the optical bands), during a quite short time (from a few days to some months), with recurrent but not periodic intervals. The behaviour of most Dwarf Novae is still unpredictable and it is quite difficult for astronomers to monitor these variables systematically. For a complete observation of the outburst cycle, one needs a total availability of the telescope for a considerable amount of time. For this reason, most of the optical observations of Dwarf Novae were carried out by amateur astronomers through visual estimations or with small telescopes equipped with CCD cameras, but the collected data are generally unfiltered or obtained with one photometric band only.

With the aim to increase our knowledge of this class of variable stars, and to supply photometric multi-band observations during the outburst cycle, we have started since 1993 the monitoring of a sample of Dwarf Novae with the 0.40 m Automatic Imaging Telescope at the Astronomical Observatory of Perugia (see e.g. Spogli et al. 1998). The observations are obtained in the B, V (Johnson) and R_c, I_c (Cousins) photometric bands, and are devoted to follow the behaviour of the optical spectral continuum during the rise and decline of the outburst.

For the faintest and less-studied objects we have also obtained data at the Astronomical Observatory of Collurania-Teramo with the 0.72 m Ritchey-Chretien

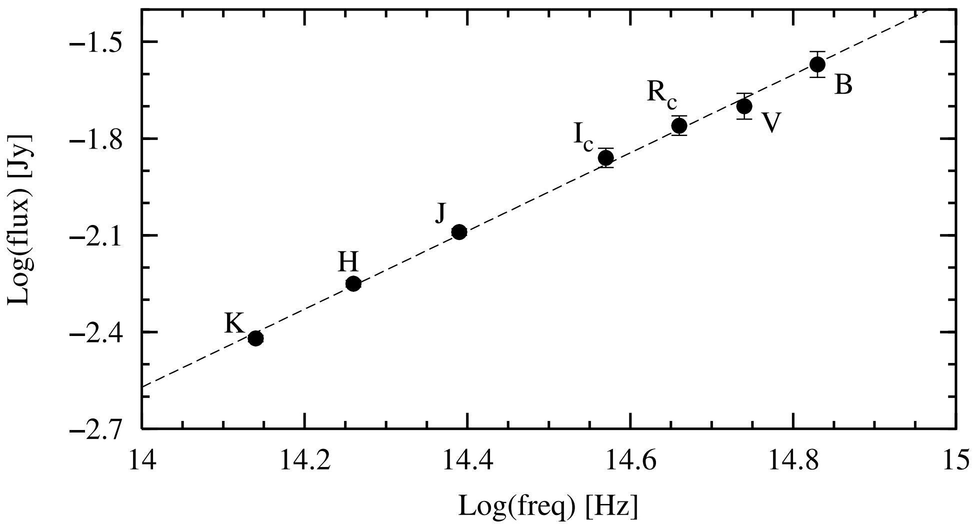

Fig. 1. BVR_cI_cJHK spectral flux distribution of AL Comae during an outburst (April 10^{th} 1995)

reflector, equipped with a similar photometric system (see e.g. Spogli et al. 2000).

Up to now we have collected data for more than 50 Dwarf Novae. This project is going on with the goal of obtaining statistical analysis of the optical spectral behaviour during all the outburst cycle. Preliminary results for individual sources have been already published (see e.g. Spogli et al. 1998, 2000, 2001). As an example we plot in Figure 1 the optical-near infrared flux distribution emitted by AL Com during a rare outburst: the continuum may be well represented by the power low $F(\nu) \propto \nu^{1.20\pm0.04}$ (see Spogli et al. 1998 for more details).

2. Unidentified extremely red objects

During the elaboration of our photometric CCD images, in the field of some Dwarf Novae, we have found the presence of very red objects ($V - I_c > 4$) which nature is unknown. Although some of these objects are located near the galactic disk, we think useful to point out their presence because the average reddening coefficient measured in the field does not seem enough to explain this phenomenon. For example, Table 1 shows the coordinates and the mean magnitudes for the objects found in the field of FY Vul and V516 Cyg. The average magnitudes have been measured with the comparison stars used for the Dwarf Nova in the field, so they may be affected by small amount of colour effects that probably cannot be greater than a few hundreds of magnitude.

Our first impression was to be in presence of reddened pre-main-sequence or post-AGB stars, because they have dust and gaseous envelopes able to absorb the visible light and re-emit in the infrared, but we expect to see some kind of variability for such types of unstable objects. Instead they do not show any relevant variability in the time-scales at our disposal (from days to a few years). This absence of variability seems to discourage our first hypothesis and suggest other suppositions and analysis.

Deep infrared and optical surveys have recently revealed a large number of extremely red objects (EROs) that form a

Table 1. VR_cI_c data of the very red objects in the field of FY Vul and V516 Cyg

Name		α (J2000)	δ (J2000)	V	R_c	I_c
FY Vul	I(1)	19 41 28.7	21 45 31	17.5±0.1	15.49±0.06	13.04±0.04
	I(2)	19 41 32.2	21 44 28	16.2±0.1	14.79±0.05	13.05±0.04
	I(3)	19 41 32.5	21 46 01	18.9±0.2	16.9±0.1	14.03±0.04
	I(4)	19 41 37.7	21 45 03	> 20	17.9±0.2	14.45±0.05
	I(5)	19 41 40.5	21 46 04	17.6±0.1	15.93±0.05	13.76±0.04
	I(6)	19 41 44.1	21 43 27	> 20	17.1±0.1	13.16±0.05
V516 Cyg	I(1)	20 47 17.7	41 56 17	> 20	17.2±0.1	13.26±0.05
	I(2)	20 47 09.7	41 55 53	19.2±0.3	16.9±0.1	13.95±0.05

Table 2. JHK_s magnitudes (2-MASS) and various near-infrared colour indices

Name		J	H	K_s	$R_c - K_s$	$I_c - K_s$	$R_c - H$
FY Vul	I(1)	10.10±0.03	8.76±0.03	8.27±0.04	7.2	4.8	6.7
	I(2)	10.91±0.03	9.83±0.03	9.49±0.04	5.3	3.6	5.0
	I(3)	10.77±0.03	9.24±0.03	8.68±0.04	8.2	5.4	7.7
	I(4)	10.70±0.03	9.17±0.03	8.46±0.04	9.4	6.0	8.7
	I(5)	11.11±0.03	9.82±0.03	9.39±0.04	6.5	4.4	6.1
	I(6)	8.99±0.03	7.31±0.03	6.58±0.05	10.5	6.6	9.8
V516 Cyg	I(1)	9.41±0.03	7.79±0.03	7.09±0.04	10.1	6.2	9.4
	I(2)	10.77±0.03	9.20±0.03	8.57±0.02	8.3	5.4	7.7

heterogeneous population. The precise definition of an ERO varies among the different surveys and depends on the particular filters employed. For example, most samples are defined by the colour index $R-K > 5-6$ (Elston et al. 1988, Thompson et al. 1999), $I-K > 4-5$ (Mohan et al. 2002), or $R_c - H > 5$ (Yan et al. 2000).

We have compared our optical data with the near-infrared data reported for the same sources by 2-MASS and available electronically at *http://vizier.u-strasbg.fr/* (see Table 2). We have always $R_c - H > 5$ and many of our objects are in agreement with more restrictive criteria too. Therefore *they can be formally considered EROs.*

Selections based on colour indices lead to a heterogeneous population, therefore EROs probably do not represent a uniform class of objects: one can find reddened cool stars together with a predominant fraction of galaxies and AGNs. For example, there are EROs at high redshifts with dusty, active star formation, as well as EROs with old stellar population. Figure 2 shows the spectral flux distributions of three objects in the field of FY Vul: it seems to see the Balmer break but with a redshift at least of z=1, then they could be very bright extragalactic objects! However, the same spectral flux distribution can be obtained by extremely reddened cool stars: we cannot rule out very high values of the local interstellar absorption A_V. In this case our data can be useful for a map of the interstellar dust.

In any case, due to the unknown nature of these objects, we are doing a census of all the EROs in the field of view of the observed Dwarf Novae, and we are planning to do specific observations in the near future, for a correct understanding and identification.

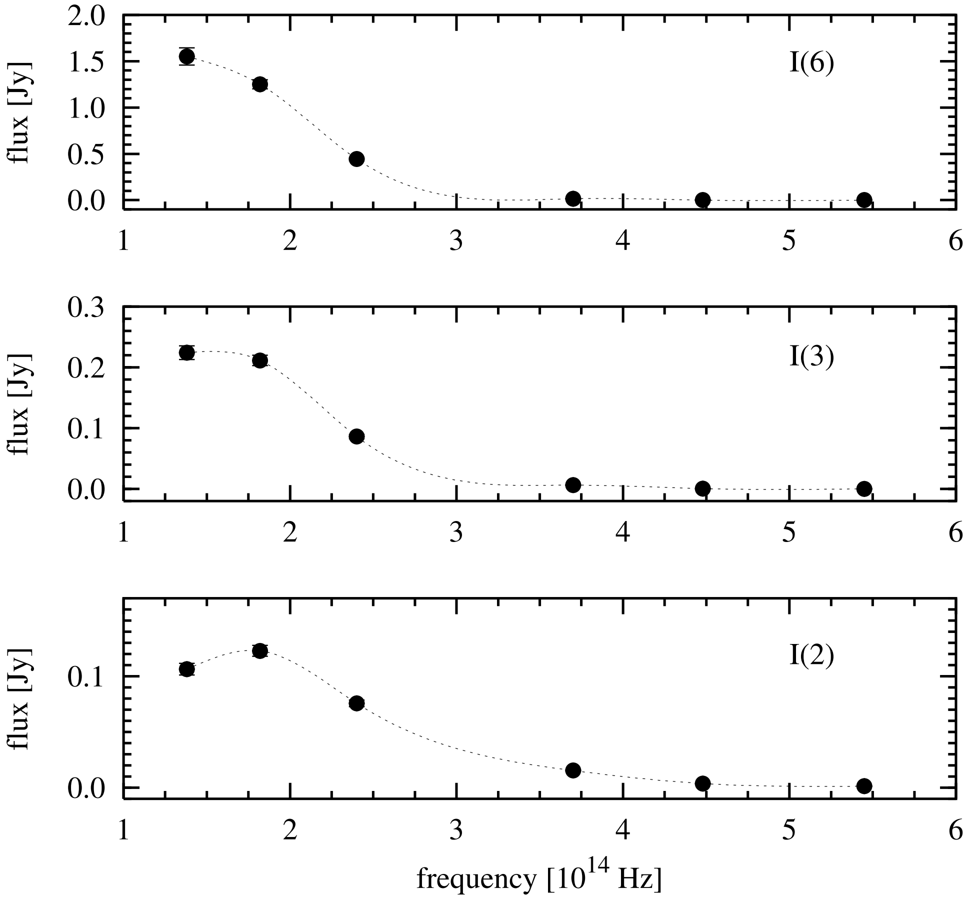

Fig. 2. $VR_cI_cJHK_s$ spectral flux distribution for three objects in the field of FY Vul: I(6) with $R_c - H = 9.8$, I(3) with $R_c - H = 7.7$, and I(2) with $R_c - H = 5.0$.

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