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# Multicolor studies of the old novae behavior

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**Abstract.** We present a result of our multicolor investigation of the old non-magnetic novae Q Cyg (Nova Cyg 1876), DI Lac (Nova Lac 1910), V446 Her (Nova Her 1960) in 1991 – 2001 and magnetic nova V1500 Cyg (Nova Cyg 1975) in 2000 – 2001. The non-magnetic novae display the outburst-like brightening in a wide region of amplitudes ($0^m.5 - 2^m.5$) and cycle duration ($\sim$ 23-d – $\sim$ 65-d). Similarly to the dwarf novae outbursts, they show a loops on the color – magnitude diagram. A shape of the loop (its width and slope) is different for different novae. In some cases the behavior of oubursts is in agreement with the model of tidal instability of accretion disk. Magnetic nova V1500 Cyg displays a strong brightening every 8.5-d, probably caused by a periodical enhancement of accretion stream and/or accretion ring surrounding the magnetic dwarf in asynchronous binary.

## INTRODUCTION

It is known that only a few patterns among known old novae display the quasy-regular brightening which look like dwarf nova outbursts, but with less amplitude. The most famous stars are GK Per [1], V446 Her, DI Lac, V841 Oph [2] . The less famous is Q Cyg [3]. There is still no common meaning on the nature of these outbursts: whether they are caused by dwarf nova-like accretion disk instabilities [4] or mass transfer events [5].

All suggestions were based on studies of the amplitude, shape and spacing of outbursts obtained from V bandpass photometry. Thus the outbursts which amplitude is comparable to those of dwarf novae are suggested to be caused by the accretion disk instability while the small-amplitude outbursts may be due to the mass transfer variations. Meanwile the Schreiber's et al. [6] simulations, taking into account irradiated accretion disk in post novae, shown that the low-amplitude ($0^m.5$!) outbursts could be also produced by accretion disk instability if the white dwarf is hot enough after nova explosion. They also shown that the cooling of white dwarf should promote increase of the outburst amplitude.

Accordingly to observations of some dwarf novae and Smak's models [7], the dwarf novae outbursts show a prominent reddening and loops on the magnitude – color diagram: the star is more red during rising brunch of the outburst and more blue during descending one. The loop is wide if the thermal instability starts in outer parts of accretion disk and propagates inward ("outward – in" instability), while narrow loop corresponds to the "inward – out" instability.

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Unlike to several dwarf novae we found no (with exception of GK Per [1]) information on the multicolor behavior of the old nova outbursts.

Here we present the results of multicolor study of non-magnetic old novae Q Cyg, V446 Her and DI Lac as well as the only known asyncronous magnetic nova V1500 Cyg [8], [9]. All the data were obtained in the Crimean Astrophysical Observatory and the Crimean Laboratory of Sternberg Astronomical Institute at 0.6-m, 0.5-m or 0.38-m telescopes with different photometric equipment: UBV-photometer , high-sensitive TV tube or CCD.

## Q CYG

Q Cyg displays the outbursts with typical cycle duration $\sim$ 65-d and variable amplitude $0^m.5 - 1^m$ [3]. Here we present observations made in 1995 – 1996 (Fig. 1,a-c). We can't define the shape of outburst because of irregularity of the time series. A behavior at the $V$, $U-B$ and $V$, $B-V$ diagrams is shown in Fig. 1 , b-c. Data which belong to different outbursts are marked by different symbols. Generally Q Cyg shows a reddening with fading by $1^m$ within the stripe of $0^m.3$ in $B-V$ and up to $1^m$ in $U-B$. Note that outburst marked by filled circles shows a broad anti-clockwise loop at $V$, $U-B$ diagram similar to the Smak's case A "outside – in" thermal instability in accretion disk. However, behavior at $V$, $B-V$ diagram does not show the loop and is rather complicated within the stripe of scattering.

## DI LAC

The outbursts of DI Lac occur every $\sim$ 36-d – $\sim$ 40-d with amplitude $\sim 0^m.5 - 0^m.8$ [2], [10]. The mean profile of some outbursts is asymmetric one with more steep ascending branch [10]. We combined data from several outbursts or their fragments occured in 1991 – 2002 together and placed them on the magnitude – color diagrams. Similarly to Q Cyg, DI Lac displays color variation within the stripe $0^m.3$ at the $V$, $B-V$ diagram, but does not displays reddening with fading. Some hint on the reddening is visible at $V$, $U-B$ diagram (Fig. 2, a,b). This effect is more prominent at $V$, $V-R$ and $V$, $V-I$ diagrams (Fig. 2, c,d), the star shows narrow clock-wise loops [10].

## V446 HER

V446 Her also shows the outbursts at a mean interval of $\sim$ 23-d [2], with variable amplitude. The largest one reaches $1^m.5$, but when corrected for the contribution from two optically close stars, amplitude is increased to $\sim 2^m.5$ [11], consistently with amplitudes of dwarf novae outbursts. Schreiber et al. [6] interpreted the large and small outbursts of V446 Her as events of thermal instability in accretion disk caused by irradiation of disk by a hot white dwarf after the nova explosion. In Fig. 3,a we present the mean profile of the largest outburst obtained by shifting the two original profiles until the best coin-

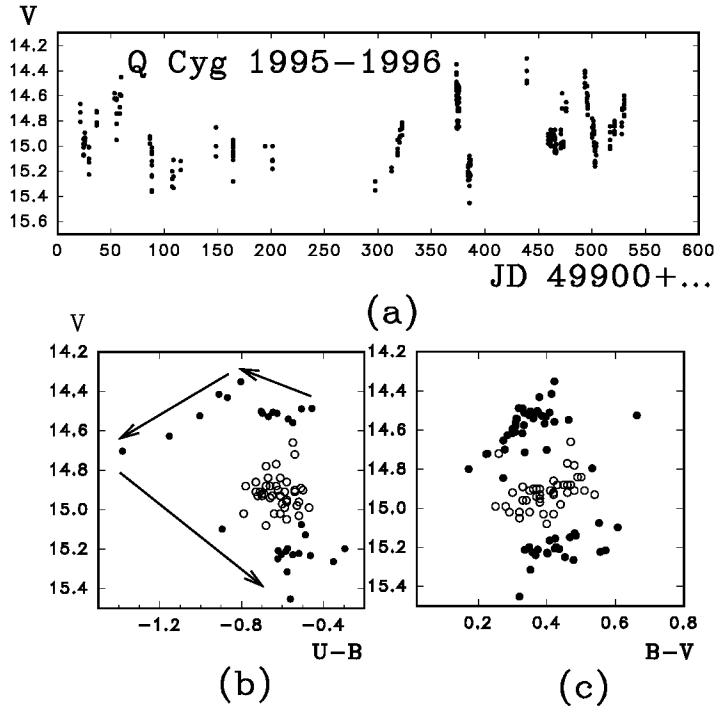


**FIGURE 1.** Q Cyg in 1995 – 1996. a)The light curve, b)$V$, $U-B$ and c)$V$, $B-V$ diagrams. The chronological development of outburst occured at JD ... 50273 – 50287 is shown by arrows.

ciding. The profile is symmetric. These two outbursts display a strong reddening with fading and very broad anti-clockwise loop at the $V$, $V-R$ diagram (Fig. 3,b). The last circumstance strengthens the idea of the dwarf nova-like outbursts of V446 Her. In the framework of the theory of thermal instability, the symmetric profile implies narrow loop and corresponds to the "inside – out" disk instability, while the "outside – in" instability shows delay of radiation at shortward wavelengths and produce an asymmetric outburst profile with a wide loop at the magnitude – color diagram [7]. The combination of the symmetric outburst profile and wide loop observed in V446 Her is somewhat unusual.

## V1500 CYG

The multicolor monitoring of the magnetic nova V1500 Cyg is very important for study the white-dwarf cooling after the nova explosion. The irradiated secondary in this binary dominates the visual flux, producing the orbital light modulation. Cooling of the white dwarf should lead to decrease of orbital amplitude with time. Somers and Naylor [12] first derived the cooling rate of the white dwarf, using B band observations, which coincided with Prialnik's theoretical prediction [13]. In Fig. 4,a we present our data

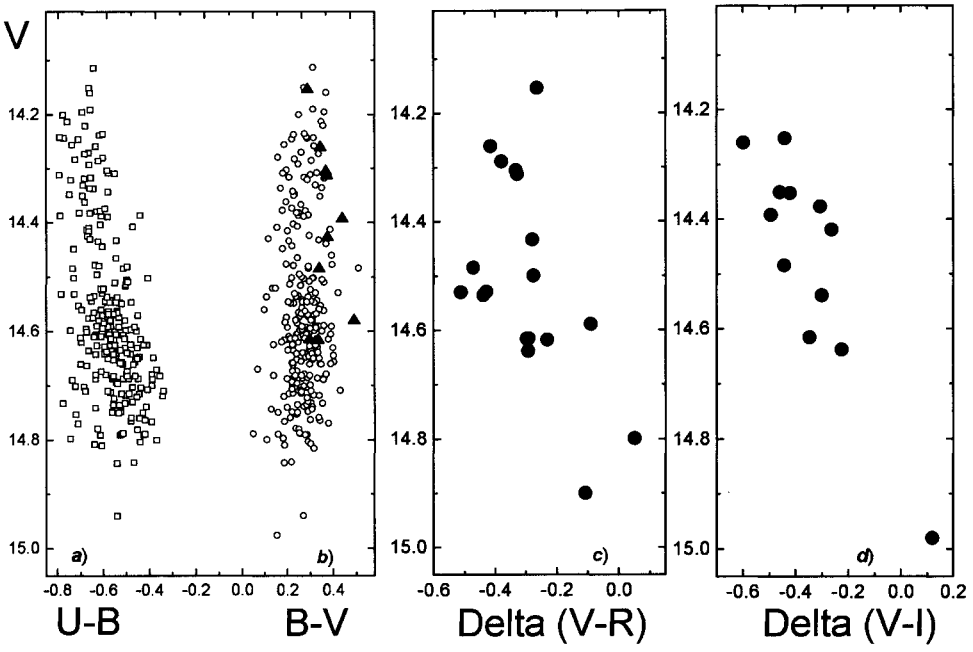


**FIGURE 2.** Behavior of DI Lac during outbursts at $V$, $U-B$ (a), $V$, $B-V$ (b), $V$, $V-R$ (c) and $V$, $V-I$ (d) diagrams.

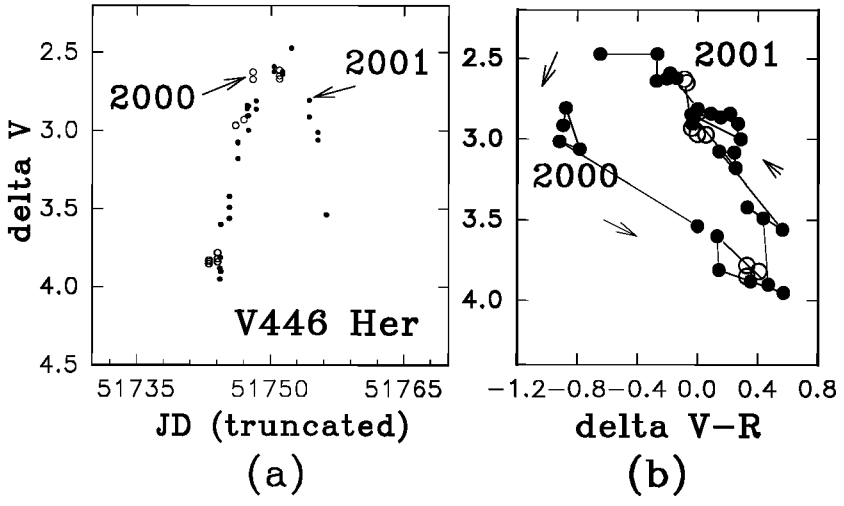


**FIGURE 3.** The mean profile of the largest outburst (a) and $V$, $V-R$ diagram (b). Data of the two separate outbursts are marked by solid and open circles.

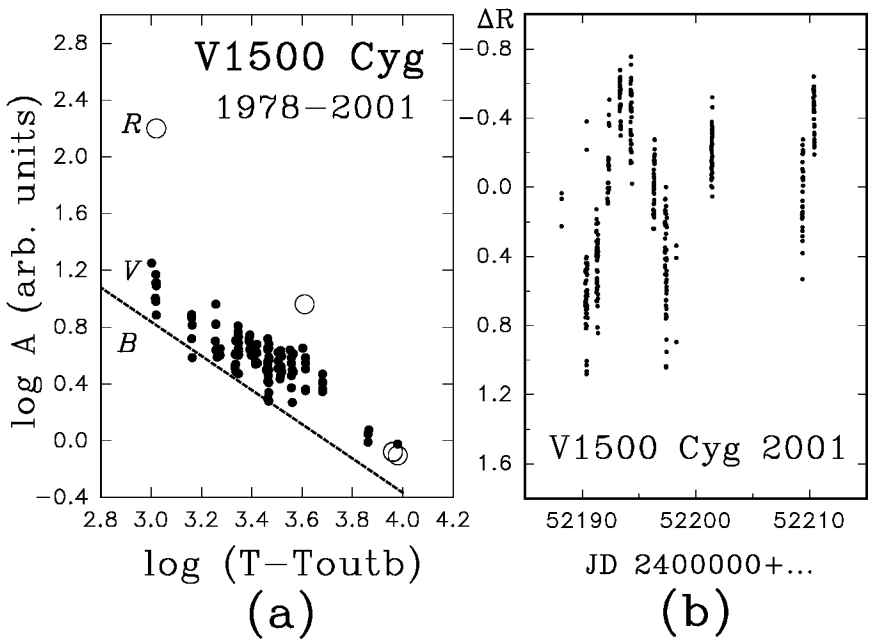


**FIGURE 4.** (a): Orbital amplitude in *B*, *V* and *R* spectral bands decrease with time passed after nova explosing (a). Data taken from [12], are drawn by line. Our *V* band data are marked by filled circles and *R* data – by open circles. All data are expressed in relative flux unites. (b): Example of the 8.5-d light modulation.

of the orbital amplitude change in *V* (filled circles) and in *R* (open circles). Note the same rate of amplitude decrease in *B* and *V*.

V1500 Cyg displays the prominent 8.5-d spin-orbital beat light variations (Fig. 4,b) caused, probably by a periodical enhancement of accretion stream and/or accretion ring surrounding the magnetic dwarf in asynchronous binary.

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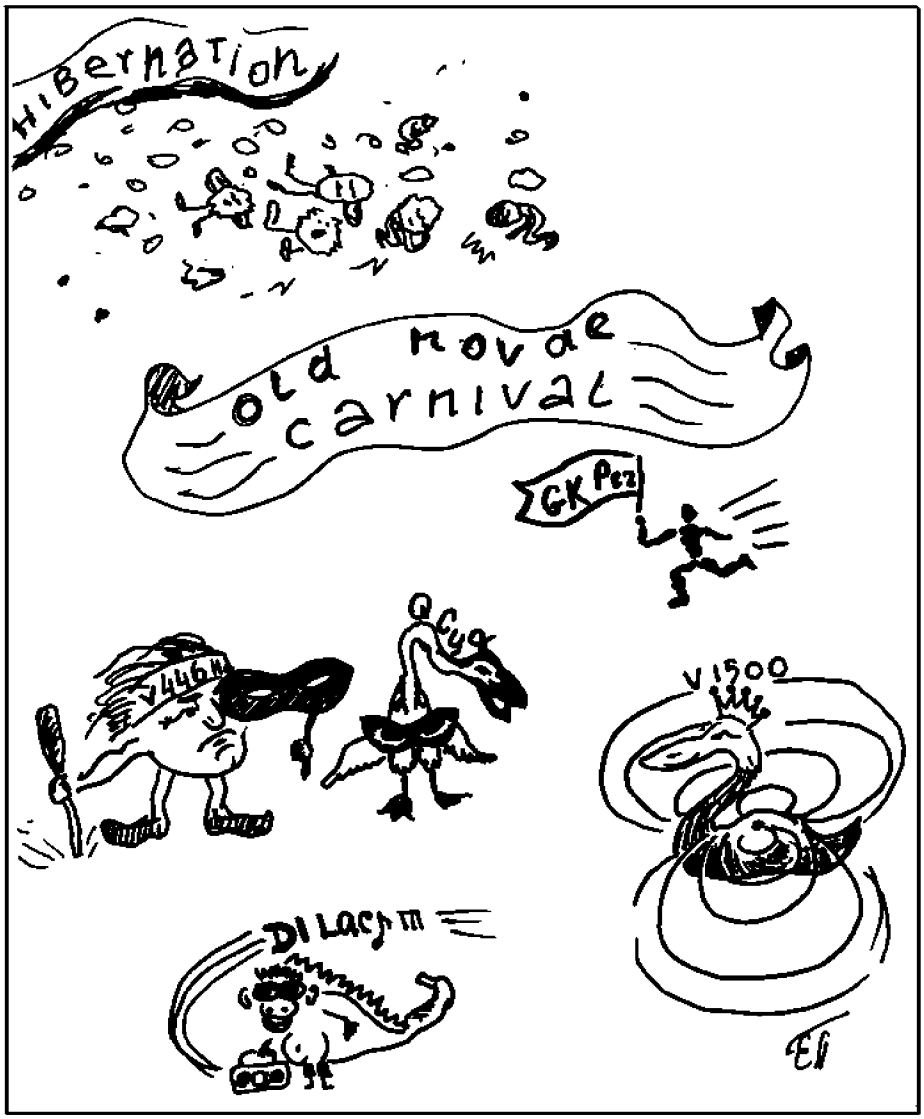


**FIGURE 5.** Only a few old novae are permitted to carnival.

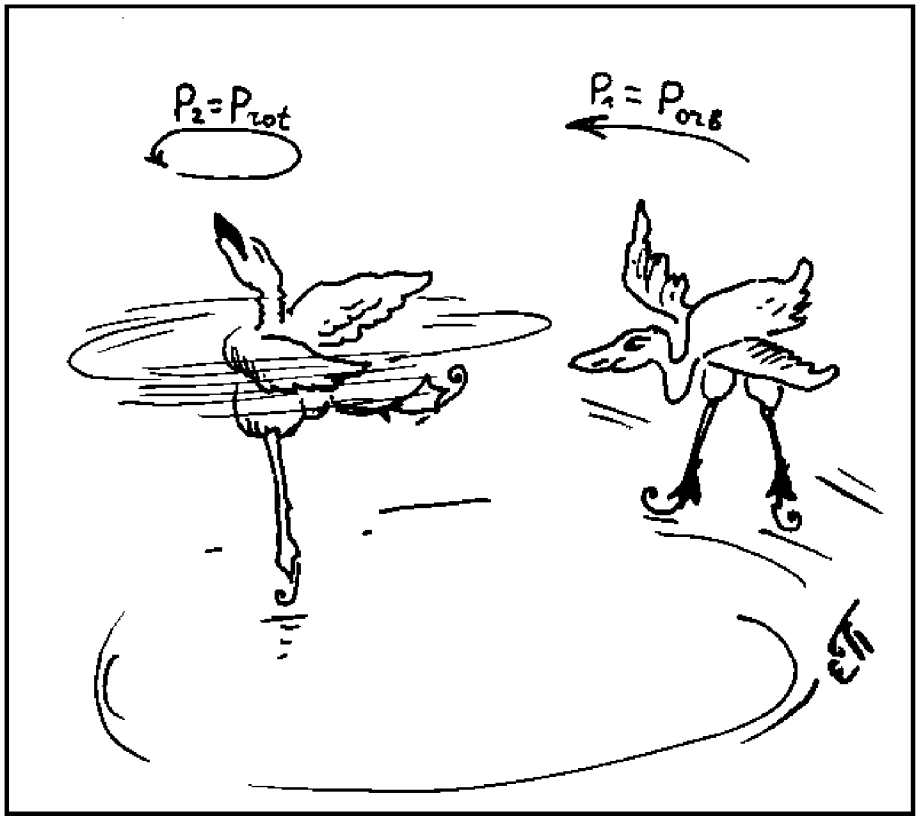


**FIGURE 6.** Asynchronous dance of V1500 Cyg.

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