OBSERVATIONS OF TYPICAL, RARE AND UNIQUE PHENOMENA IN CLOSE BINARIES WITH EXTREMAL MASS RATIO

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ABSTRACT. We present the review of different properties of several close binary systems, based on our observations. These binaries are as follow: SU UMa type stars V503 Cyg and V1504 Cyg, X-Ray novae V518 Per and V404 Cyg. They have the extremal mass ratio of the primary component to the secondary $M_1/M_2 > 3$. Some of them show the typical for the SU UMa type stars behaviour, so-called the "positive superhumps" or more rare "negative superhumps". Another display the "forbidden" variability in the ordinary outbursts or the light variation of unknown yet nature.

Key words: Stars: binary: cataclysmic, X-ray novae; stars: individual: V518 Per, V404 Cyg, V503 Cyg, V1504 Cyg.

1. Introduction

25 years ago some phenomenon - the "superhump" phenomenon - was discovered in a long, or superoutburst of the SU UMa dwarf nova VW Hui (Vogt 1974, Warner 1975). Superhumps are periodic light modulations appearing soon after maximum light of the superoutburst, not in the ordinary outburst (the last occure more frequently and have the shorter duration in respect to the superoutburst). Their periods (P_sh) are between 1 and 7 per cent longer then the binary orbital period (P_orb). At the start of superoutburst they have the highest amplitude (sometimes up to $0^m.5$), decaying on a time-scale of a week. The nonsinosoidal puls shape becoming increasingly sinusoidal as the amplitude declines. Accordingly the accepted models (Whitehurst 1998, Hirose and Osaki (1990), Whiterhurst and King (1991), Lubow (1991a,b, 1992), Osaki (1994)), an accretion disk expands to the "instability radius"- 3:1 resonance radius, transforms to an elliptical structure and slowly precess in the binary reference frame. Superhumps are generated by viscous dissipation due to the tidal stressing of the accretion disk by the secondary with a period which is slightly longer than the orbital period due to the precession of the disk.

The model demands the extremal binary mass ratio $q = M_1/M_2$ to be larger than 3 for superhump appearence. So one could believe to see this phenomenon not only in the SU UMa type stars, but in all cataclysmic binaries with such mass ratio.

Besides of common or "positive" superhumps mantioned above (more than 50 targets) there are 11 systems which show more rare "negative" superhumps (Patterson, 1998) with $P_{sh} < P_{orb}$, perhaps, caused by the nodal precession of the accretion disk (Bonnet-Bidaud et al., 1985, Udalski, 1987).

2. Observations

Here we present the behaviour of four binaries - real or potential "superhumpers". They are: the SU UMa type stars V503 Cyg and V1504 Cyg, and X-Ray binaries V518 Per and V404 Cyg. The observations were obtained by authors in Crimean astrophysical observatory (CrAO) and in Crimean laboratory of Sternberg astronomical institute (SAI). The journal of observations is given in the table. There the name of binary, year of observation, telescope and spectral band are given. MTM-500 means the 500-mm meniscus Maksutov telescope of the Crimean observatory (CrAO), equipped with the blue-sensitive TV system (Abramenko et al, 1998), K-380 and B-200 are the CrAO - SAI 380 mm

Table 1: The journal of observations

Binary	Date	Telescope	spectral band
	multicolumn caption		
V503 Cyg	1997	MTM-500	"BV"
V1504 Cyg	1997-99	MTM-500	"BV","RI"
		K-380	
		B-200	
V518 Per	1994	MTM-500	"BV"
V404 Cyg	1998	K-380	"RI"

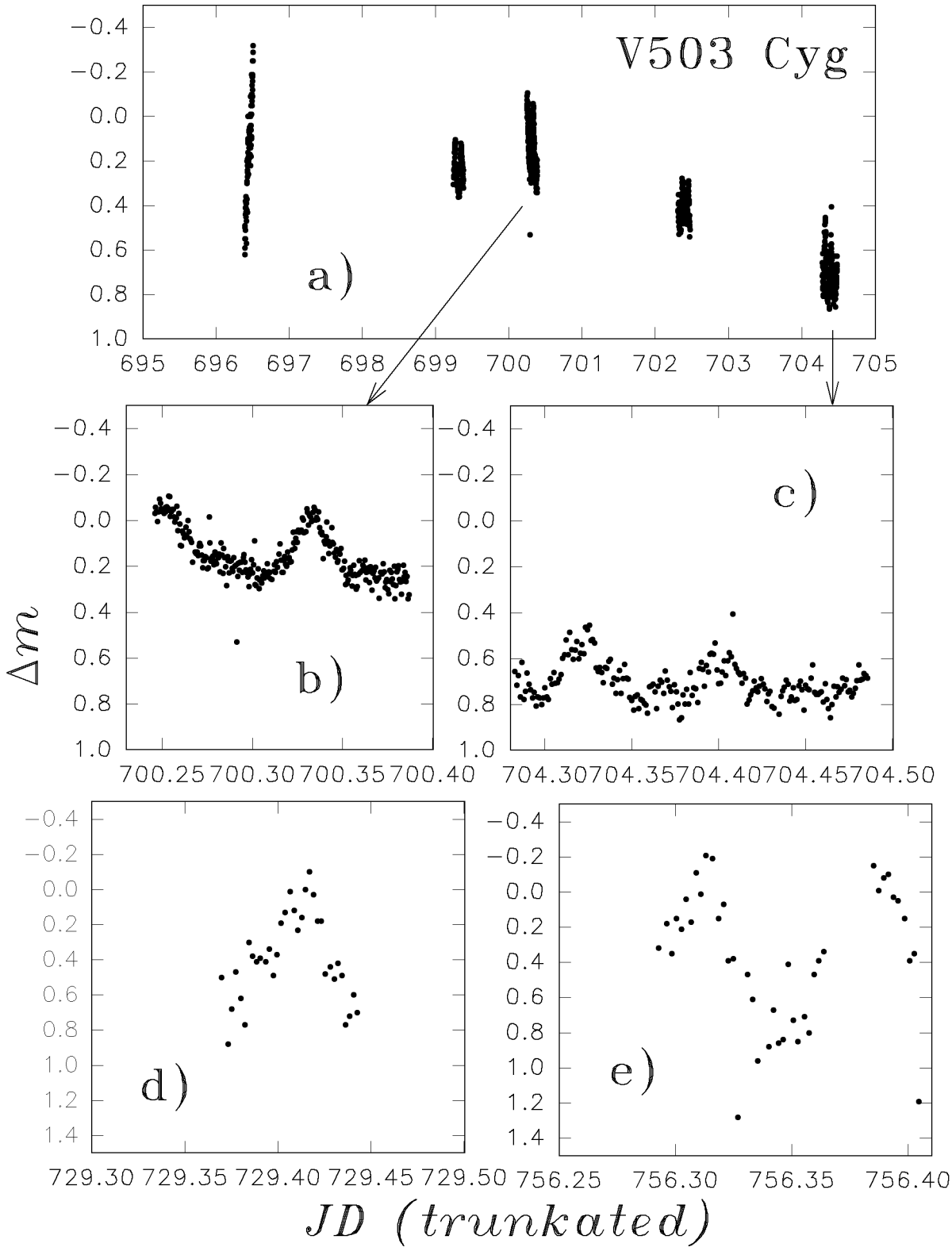

Figure 1: V503 Cyg in the superoutburst and low brightness state: a) the light curve of superoutburst; b) and c) the positive superhumps; d) and e) the nrgative superhumps. The brightness is given in respect to the comparison star. In the superoutburst and in the low state we used two different comparison stars.

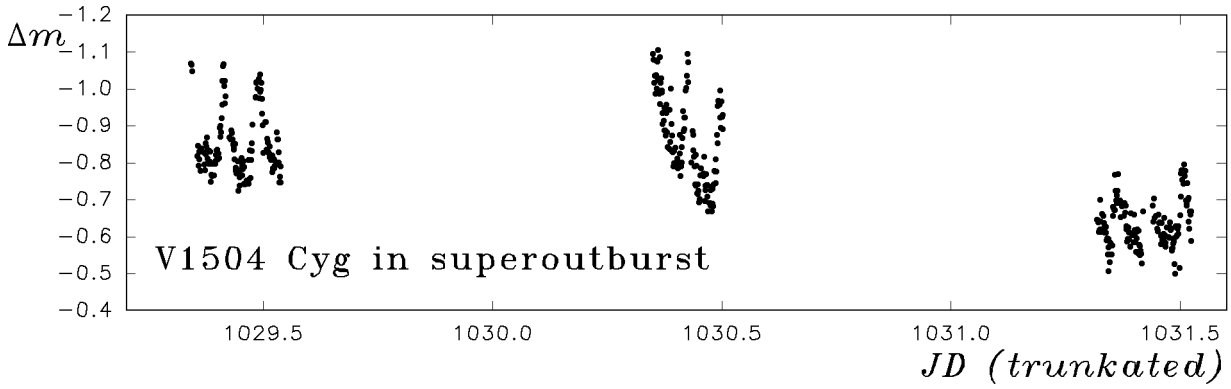

Figure 2: The light curve of V1504 Cyg in the superoutburst in 1998

and 200 mm telescopes respectively, equipped with the red-sensitive CCD ST-7. The TV - observations have been carried out in the broad spectral region including B and V standard band ("BV"), and the CCD - observations were made in the broad "RI" band.

3. SU UMa-type stars

3.1 V503 Cygni

We observed the V503 Cygni during 5 nights in superoutburst and two nights when the system was in the low brightness state. The superoutburst light curve is shown in the Fig.1,a. The star demonstrated the so-called common or positive superhumps (see Fig.1 b,c) with amplitude of $0^m.3$ and period of 117 min. In the minimum we observed another light periodicity - the "negative superhumps" with amplitude of 1^m (Fig.1 d,e). The behavior of V503 Cyg both in the superoutburst and low brightness state in detailes resembles to those studied by Harvey et al. (1995).

3.2 V1504 Cygni

We present the result of observations of V1504 Cygni in low brightness state, during ordinary outburst and during superoutburst. The superoutburst itself is performed in Fig.2. In superoutburst the star displays the light variations with $P_{sh} = 0.07d$ (Nogami, 19997). In ordinary outburst occured in July, 1998, we had observed light variations with $P = 2 * P_{sh}$. One night we made the simultaneous observations in "BV" and "IR" color bands and can't conclude that behaviour in blue and red spectral region is similar. The amplitude of light variation in "RI" band is at least two times less than in "BV" (Fig.3). Another ordinary outburst observed in September, 1998 in "RI" only, did not show any light modulations just as it is observed among the SU UMa stars.

Note that in minimum the star shown the light modulation close to the $1/2 * P_{orb}$ with variable amplitude Pavlenko et al., 2000).

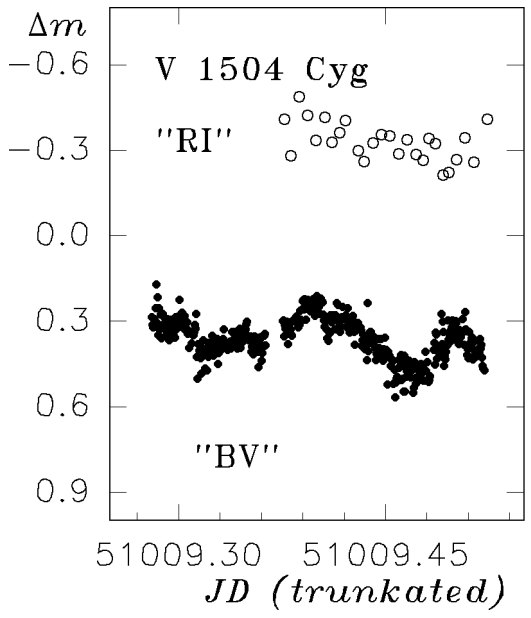

Figure 3: V1504 Cyg in the ordinary outburst.

4. X-Ray Novae

4.1 V518 Per

The long-term behaviour of the X-Ray nova V518 Per during the first two years after the outburst was similar to those of SU UMa type stars: after the long-lasted outburst (over 200 days) the star rapidly faded to the 20^m or less, and the next year erupted twice for a respectively short time (see the overall light curve in Shrader et al., 1995). It was the first X-Ray where the superhumps with $P_{sh} = 5.1h$ were detected by Kato et al.(1995) three months after superoutburst. The orbital period of the system was accurately established by Chevalier and Ilovaisky (1995). However this binary shows unexplained yet photometrical periods. Thus Martin et al. (1995) observed the star in minimum between the two otbursts and did not find any signs of orbital light variations. Instead he detected the $16.2-h$ periodicity.

We also observed this star during the 5 nights in the last mini-outburst occured in January 1994 (see Fig. 4), when the mean brightness of the binary was close to 18^m. The time series analysis yieled the most signigicant period of $5.4h$, but not $5.1h$ (see Pavlenko, Sharipova, 2000 for details)! The data, folded on this period are presented in Fig.4. Note that the $5.4h$ period is three times less of $16.2h$ period, so, probably, it is the harmonic of the unexplained periodicity mentioned above.

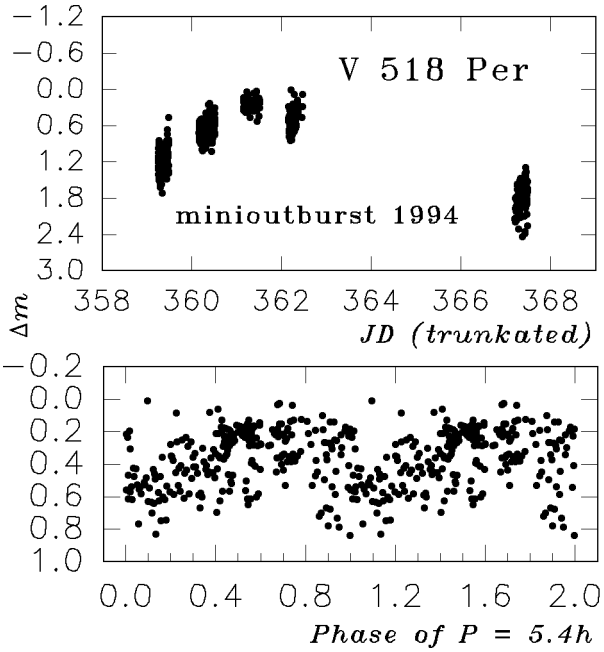

Figure 4: V518 Per during the last (1994 year) minioutburst: The overall light curve (top panel) and the data of one night (JD =...362), folded on the 5.4h period (low panel).

4.2 V404 Cyg

The orbital period of V404 Cyg is rather long among the X-ray novae ($6.47d$), so the superhumps period was not detected during the past outburst. However this binary shown another puzzling quasy-periodic strong light variations with typical time of 6 hours and amplitude up to $0^m.3$ (Pavlenko et al., 1996). The assumption was that the source of the 6-h modulation is localized in the accretion disc and connected with some non-stacionary accretion process. We observed V404 Cyg again in 1998 during subsequent 12 nights and found that the 6-hours variations, which existed for several years after outburst, to the end of decade significantly reduced its amplitude, or disappeared at all.

5. Conclusion

We summarised the different properties of the two dwarf novae and two X-ray novae with the high mass ratio ($M_1/M_2 > 3$) obtained from our observations. We could conclude that V503 Cyg recover its behaviour - the common superhumps in superoutburst and the negative superhumps in quiescent state from year to year. V1504 Cyg SOMETIMES shows "forbidden" light variations over the duration of the ordinary outburst at least in the "BV" spectral region with typical time of twice the superhump period. X-ray novae show the transient light variability of unknown nature.

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