CCD-PHOTOMETRY OF THE CATACLYSMIC VARIABLE V2275 CYGNI IN 2003

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ABSTRACT. Results of CCD R-photometry of the nova V2275 Cygni obtained in summer, 2003 are reported. There are two candidate periods $P = 0.^{d}46566(18)$ and $0^{d}.87281(72)$ with corresponding amplitudes $0.^{m}180(5)$ and $0.^{m}174(5)$ and initial epochs for the maxima HJD 52825.3962(26) and HJD 2452825.3254(59), respectively. At shorter time scales, the system shows the highest peak corresponding to the period 25.0572(18) minutes, semi-amplitude $0.^{m}026(4)$ and initial epoch HJD Max=2452825.39846(44). The daily biases with frequencies $f = 57.468 + j$ may not be excluded. If this period corresponds to a coherent wave, the system may be classified as an intermediate polar with this period (or a double one 50.12 minutes).

Key words: Stars: binary: cataclysmic: novae; stars: individual: V2275 Cyg

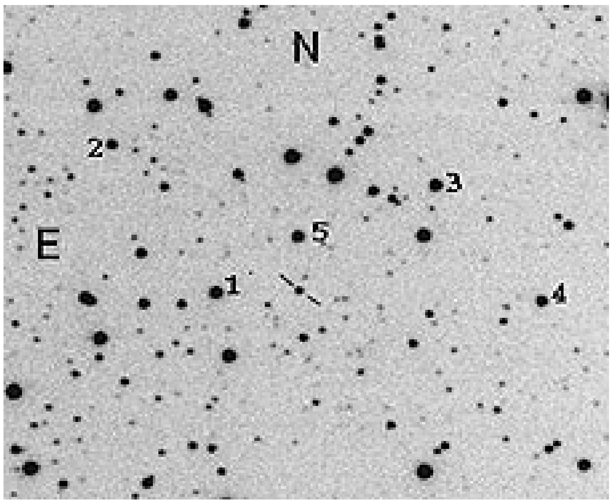

Figure 1: A finding chart for V2275 Cygni and comparison stars.

1. Introduction

A cataclysmic variable (CV) is a close binary system in which mass transfer occurs. The primary, a white dwarf, receives mass from the secondary, a late type main sequence star which fills its Roche Lobe and transfers mass through the inner Lagrangian point of the system. In order for the mass to conserve angular momentum, an accretion disk forms around the primary (in non-magnetic systems). In system, where the white dwarf is magnetic ($B \geq 10$MG), the magnetic fields disrupts the formation on an accretion disk and either only a partial disk is formed (intermediate polars) or the material directly impacts the surface of the white dwarf (polars). When thermonuclear runaway occurs on white dwarf ... arise Nova outburst.

Nova Cygni 2001 was discovered by A. Tago and K. Matayama on Aug. 18 (Nakamura, 2001) at a magnitude of $6.^{m}6$. The brightness decay from maximum was one of the fastest ever recorded and it shows characteristics of recurrent novae (Kiss et al., 2002). Balman et al. (2003) report that R-band CCD photometry, obtained during 2002 reveals the presence of large variations in the light curve of this nova with a period of either $0.^{d}463 \pm 0.^{d}014$ day or $0.^{d}316 \pm 0.^{d}007$, which might be associated with its orbital period. The semi-amplitude of the variations is about $0.^{m}5$.

This paper presents results of analysis of CCD R-observations V2275 Cygni in summer 2003.

2. Observations

Our observations of V2275 Cyg have been carried out at the 60cm telescope of the Crimean Laboratory of Sternberg Astronomical Institute equipped with a CCD camera AP7 in the R filter. CCD was binned 1×1 providing a scale of 0.8 arcsec/pixel and sometimes 2×2. The field of view is 6' on a side. The exposure time varied from 90 to 150 sec. The start and the end of observations, exposure time and number of measurements are listed in Table 1. The resulting images were bias–subtracted and flat–fielded and instrumental magnitudes were measured using the program WINFITS by V.P.Goranskiy realizing the aperture photometry.

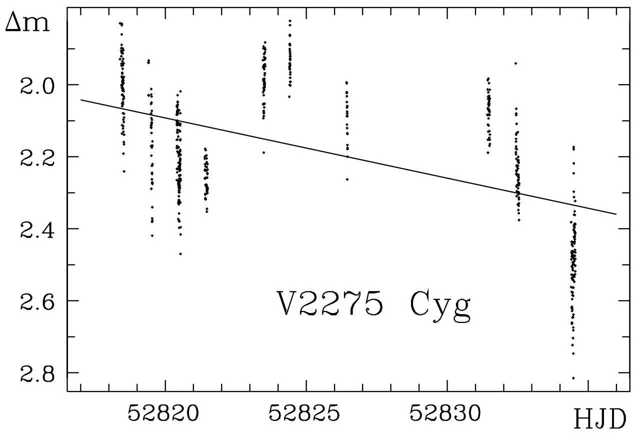

Figure 2: Light curves for all nights. The line corresponds to the trend.

Totally 567 brightness estimates have been obtained during 10 nights (HJD 2452818.39 – HJD 2452834.54). At the beginning of observations, the star was 679 days after the maximum light.

Table 1: Journal of observations.

JD, 24...	JD, 24...	t_{exp}, sec	N
52818.3954	52818.5409	120	68
52819.4036	52819.5476	120	43
52820.4025	52820.5465	90	114
52821.4009	52821.5042	90	40
52823.4624	52823.5436	120	50
52824.4005	52824.4398	90	32
52826.4283	52826.4642	120	23
52831.4221	52831.5123	150	44
52832.4275	52832.5468	120	58
52834.3935	52834.5442	120	95

Five comparison stars near the nova (Figure 1) have been measured. To obtain better accuracy, we have used the "artificial" ("mean weighted") star using the program "MEAN_S" by I.L.Andronov (2003), instead of one comparison star. The weights have been iteratively computed inverse proportionally to the square of the statistical error: $w_\alpha = \sigma_\alpha^{-2}$. The list of the mean values of the instrumental magnitudes in respect to the "main" comparison star "1".

The unbiased r.m.s. magnitude error of the mean weighted comparison star is $0.^{m}007$, so at least twice better than any of individual comparison stars. From our observations, the star "5" seem to be more stable than the brightest star "1". The faintest star "2" shows the largest scatter.

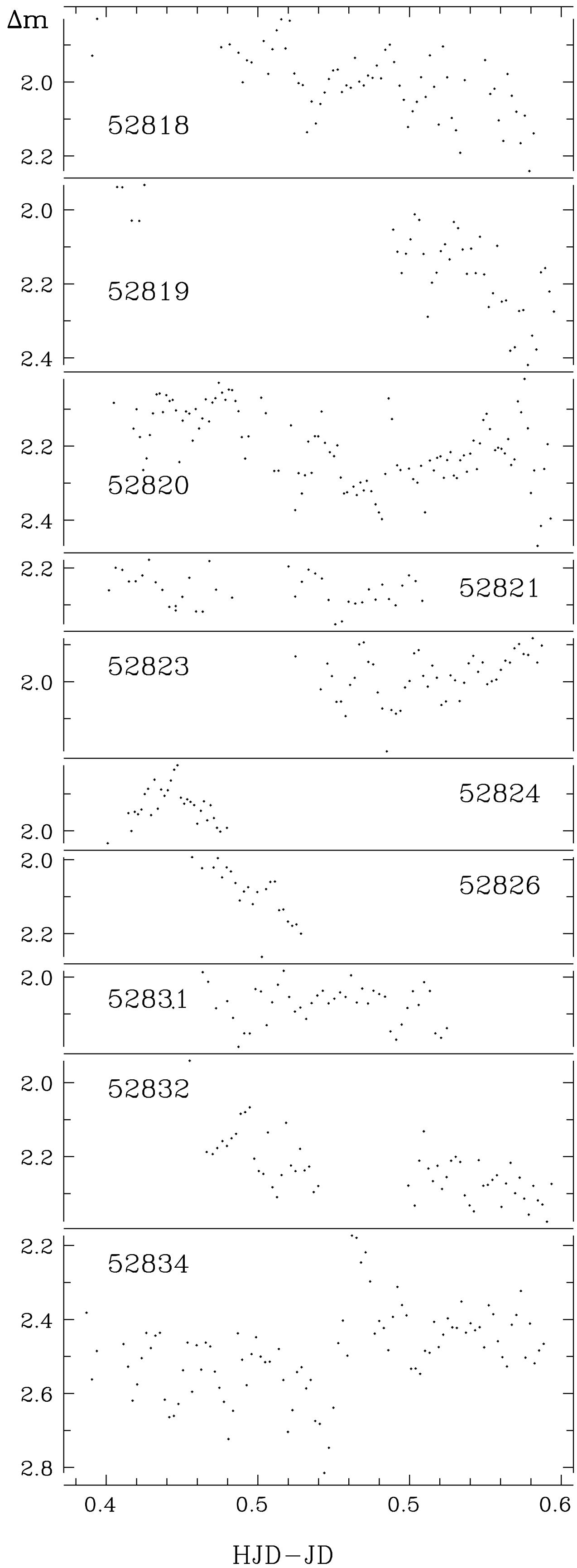

Figure 3: Individual light curves for separate nights. Abscissa is the fractional part of the date.

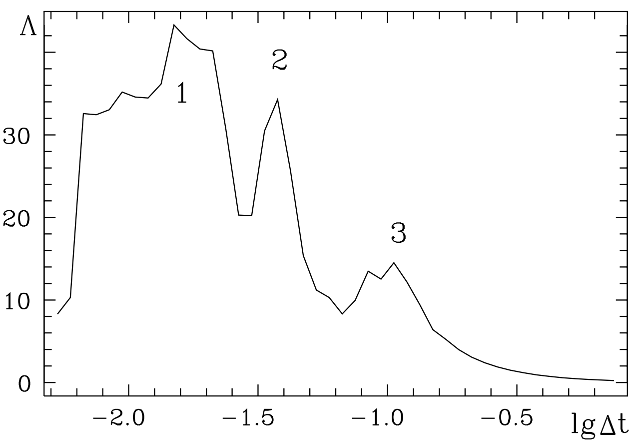

Figure 4: Λ−scalegram (Andronov 2003) for original observations. For scaling purposes, the ordinate is $10^4\Lambda$ instead of Λ. The characteristics of the peaks are the filter half-width Δt, corresponding value Λ, effective "period" $P_{eff} = \Delta t/1.106$ and "semi-amplitude" $R_{eff} = \sqrt{\Lambda/2.52}$:

Peak	Δt	Λ	P_{eff}	R_{eff}
1	$0\overset{\mathrm{d}}{.}0155$	0.0044	$0\overset{\mathrm{d}}{.}0140$	$0\overset{\mathrm{m}}{.}0416$
2	$0\overset{\mathrm{d}}{.}0368$	0.0035	$0\overset{\mathrm{d}}{.}0332$	$0\overset{\mathrm{m}}{.}0370$
3	$0\overset{\mathrm{d}}{.}1054$	0.0015	$0\overset{\mathrm{d}}{.}0953$	$0\overset{\mathrm{m}}{.}0240$

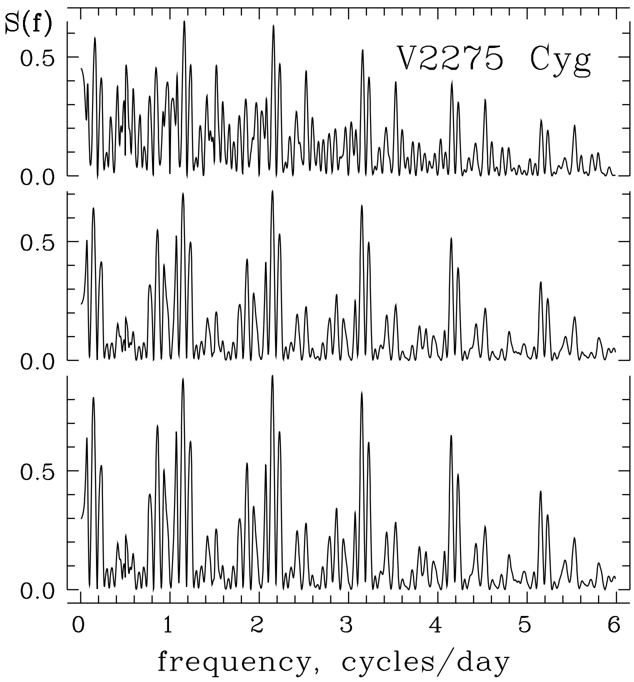

Figure 5: Periodograms $S(f)$ for initial data *(up)*, data with linear trend removed *(middle)* and the deviations of the "running parabola" fit with $\Delta t = 0\overset{\mathrm{d}}{.}15$ from the linear trend *(bottom)*. One may note equidistant peaks at frequency $f = j + 0.148$ cycles/day, which are daily biases of one best period.

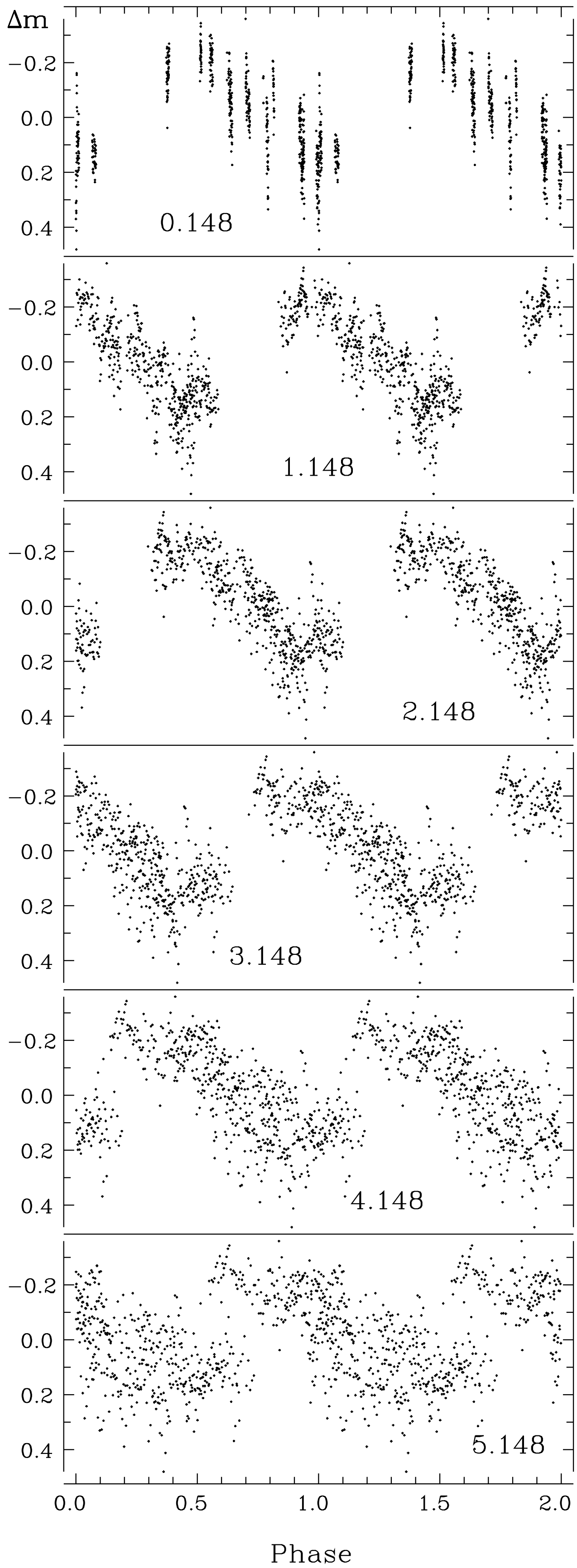

Figure 6: Phase light curves for V2275 Cyg for the bias frequencies $f = j + 0.148$ cycles/days, where $j = 0..5$.

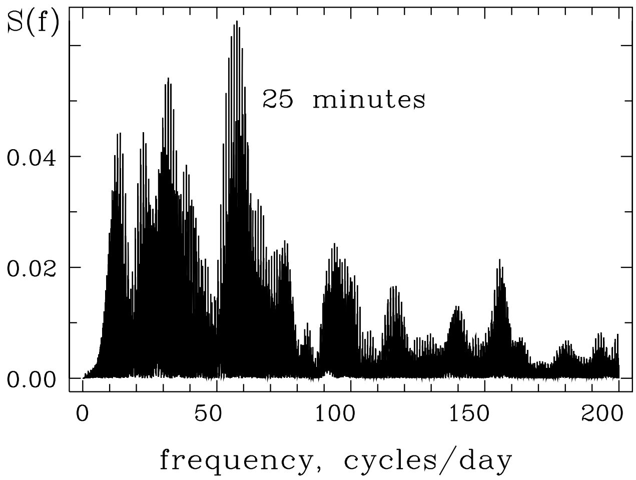

Figure 7: Periodogram $S(f)$ for deviations of observations from the "running parabolae" fit with $\Delta t = 0\overset{d}{.}15$.

Table 2: Mean magnitudes of comparison stars in respect to the star "1" and r.m.s. accuracy estimate

Star	$\langle m \rangle$	error
1	$0\overset{m}{.}000$	$0\overset{m}{.}016$
2	$1\overset{m}{.}032$	$0\overset{m}{.}031$
3	$0\overset{m}{.}117$	$0\overset{m}{.}015$
4	$0\overset{m}{.}509$	$0\overset{m}{.}015$
5	$0\overset{m}{.}317$	$0\overset{m}{.}012$

3. Time Series Analysis

3.1. General Photometric Behaviour

The light curve for a complete set of observations obtained in summer, 2003, is shown in Fig. 2. It shows a trend corresponding to the continuing weakening of the star during our observations at a mean rate $dm/dt = 0.0167 \pm 0.0011$ mag/day (14σ deviation from zero). To avoid bias of the trend onto results of periodogram analysis (cf. Terebizh 1992), we have made a second "observational set" from the residuals of the original data from the best fit linear trend.

The light curves for individual nights are shown in Fig. 3. They exhibit variability at time scales both longer than the duration of observations and shorter.

3.2. Scalegram Analysis

The scalegram analysis has been carried out using the "Running Parabola" fit with additional weight functions (Andronov 1997). To look for characteristic time scale of possibly aperiodic variations, we have computed an advanced "$\Lambda(\Delta t)$" scalegram (Andronov 2003). A part of it is shown in Fig.4.

There are 3 distinct peaks at time scales shorter than one day. The "effective" periods (i.e. the periods of a sine curve having a peak at $\Lambda(\Delta t)$ at the same value of filter half-width Δt) are 20, 48 and 137 minutes, respectively. It should be noted, that the $\Lambda(\Delta t)$ scalegram has bad frequency resolution, as had been elaborated for signals of low coherence. However, the 20-minute wave seem to have the largest amplitude.

3.3. Search for Long Periods

For the periodogram analysis, we have used the program Four-1 (Andronov 1994) realizing least squares (LS) fitting of sine with unknown mean, amplitude and phase. To check influence of trend, we have used two trend-affected sets in an addition to the original data. The periodograms $S(f)$ (square of the correlation coefficient between the observed and computed signal values) are shown in Fig. 5. All of them show a set of equidistantly separated peaks at frequencies $f = j + 0.148$ cycles/day, where j is an integer. These are the daily biases of some peak.

The phase curves corresponding to $j = 0..5$ are shown in Fig.6. There are two peaks of nearly same height for $j = 1$ and $j = 2$. Using non-linear LS fit using differential corrections in frequency, the values of the period P, semi-amplitude R and initial epoch for the maximum brightness have been obtained, which are listed in the Abstract. For present data, we may not distinguish between these two periods.

3.4. Search for Short Periods

The periodogram $S(f)$ for the deviations of data from the "Running Parabola" fits with $\Delta t = 0\overset{d}{.}15$ (which is sufficient to approximate "long" variations) is shown in Fig. 7. There is a prominent set of peaks, the highest of which corresponds to the period $0\overset{d}{.}0174008(13)$, semi-amplitude $0\overset{m}{.}026(4)$ and initial epoch $HJDMax = 2452825.39846(44)$. However, the daily biases with frequencies $f = 57.468 + j$ may not be excluded. If this period corresponds to a coherent wave, the system may be classified as an intermediate polar with a period 25.0572(18) minutes (or a double one 50.12 minutes).

Acknowledgements. The authors are thankful to V.P.Goranskiy for his program for CCD reduction. The research was partially supported by the DKNT grant 02/07/00451.

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