MULTICOLOR PHOTOMETRY OF THE CLASSICAL NOVA V446 HER IN "QUIESCENCE"

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ABSTRACT. We present the result of 2-year observations of Nova Her 1960 = V446 Her in 2002 - 2003. Data obtained in VRI spectral bands display the dwarf-nova-like outbursts with amplitude $\sim 1^m$ - 1.8^m and typical time of 14 days. The magnitude - color diagrams show the reddening with fainting. They support the idea that the nature of the outbursts could be the thermal instability in accretion disk around white dwarf.

Key words: Stars: binary: cataclysmic; stars: individual: V446 Her.

1. Introduction

The classical Nova V446 Her (Nova Her 1960) belongs to these unique novae which in quiescence display regular dwarf-nova-like outbursts. Another similar novae are DI Lac (Pavlenko et al., 2002), V841 Oph (Honeycutt et al., 1995), GK Per (Bianchini et al., 1986), Q Cyg (Shugarov, 1983). Schreiber et al. (2000) suggested that the nature of V446 Her outbursts is the same as in ordinary dwarf nova , i.e., results from thermal instability associated with hydrogen ionisation in accretion disc. Authors believe that irradiation of the accretion disc by the hot white dwarf limits the surface of accretion disc participating in the thermal instability and, hence, limits the outburst amplitude. We have undertaken a long-term multicolor monitoring of V446 Her in order to obtain the characteristics of the separate outbursts and compare result with theoretical prediction.

2. Observations

Observations have been carried out in the Crimean astrophysical observatory in 2002 - 2003 at K-380 Cassegrain telescope with CCD SBIG ST-7 and in the Crimean Laboratory of Sternberg Astronomical Institute in the Johnson VRI spectral band. Totally V446 Her was monitored during 89 nights.

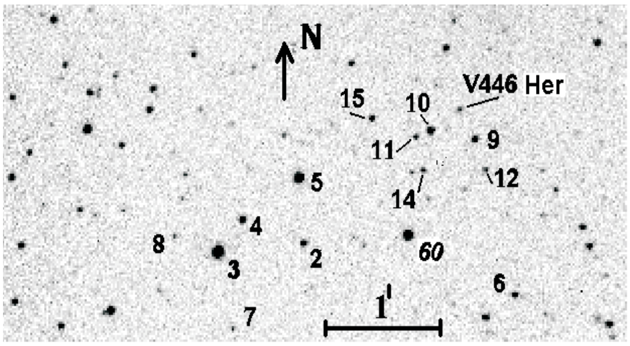

Figure 1: The finding chart for the V446 Her and secondary standard stars.

3. Secondary standards

We took data for 10 nights obtained with the same exposure 240 sec both in V and R band. For every night we selected about 14 stars around V446 Her (see Fig.1) and measured their V and R magnitude. As a standard star we used the star USNO B1.0 1330-0403616. Its magnitudes are: V = 15.32^m, R = 14.65^m which were obtained by Shugarov S. Yu. (Pavlenko, 1999). The comparison star for V446 Her was the star number

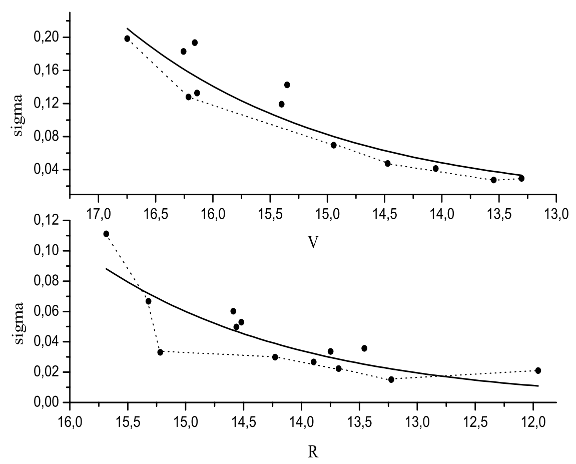

Figure 2: The dependence of standard deviations σ on magnitude.

60 according to the numbering by A. Henden. It has V = 12.63^m and R = 12.04^m that differ on $0^m.03$ (in V) from Henden's measure (V = 12.60^m, private communication).

Table 1: The V, R, V-R magnitudes and their standard deviations σ.

N	R	σ_R	V	σ_V	V-R	σ_{V-R}
2	13.749	0.0107	15.351	0.0475	1.602	0.0487
3	–	–	13.303	0.0104	–	–
4	13.457	0.0113	14.945	0.0232	1.488	0.0258
5	11.956	0.0066	13.546	0.0092	1.59	0.0114
6	13.68	0.0085	14.474	0.018	0.794	0.0199
7	15.321	0.0253	16.138	0.0443	0.817	0.0509
8	15.219	0.0117	–	–	–	–
9	13.895	0.0084	15.801	0.0765	1.906	0.077
10	13.225	0.0048	14.054	0.0138	0.83	0.0146
11	14.519	0.0168	15.4	0.0397	0.881	0.0431
12	14.588	0.0191	16.159	0.0685	1.571	0.0711
13	15.685	0.0351	16.749	0.081	1.064	0.0883
14	14.563	0.0157	16.213	0.0426	1.65	0.0454
15	14.228	0.0095	16.256	0.0609	2.028	0.0617

In Table 1 we gave the measured magnitudes in R, V Johnson standard system, their V-R color and correspondent standard deviations. The obtained standard deviations represent the outer accuracy:

$$\sigma = \frac{\sqrt{\sum_{i=1}^{k}(\Delta m_i - \overline{\Delta m})^2}}{k-1}, \qquad (1)$$

where
σ - standard deviations;
Δm_i - the difference between measured magnitudes of selected star and star number 60.
$\overline{\Delta m}$ - average difference over all observed nights.
k - number of nights.

We also plotted the sigmas of a *single* (sigma = $\sigma/\sqrt{k}$) observation against correspondent magnitude in V and R (see Fig. 2, a,b). One can see that the points are spread within some streap, where sigma grows whith magnitude. The dotted line is drawn through all points including possible variable stars with small amplitude. The solid line is the low envelope of the points which, perhaps, more realistically represents the dependence of accuracy from magnitude. In this case the stars above curve could be variable. The best accuracy for exposure time 240 sec was $0^m.02$ in the range of R = 12.0^m and $0^m.04$ in the range of V = 13.5^m. These dependences will be useful for the V446 Her error estimation.

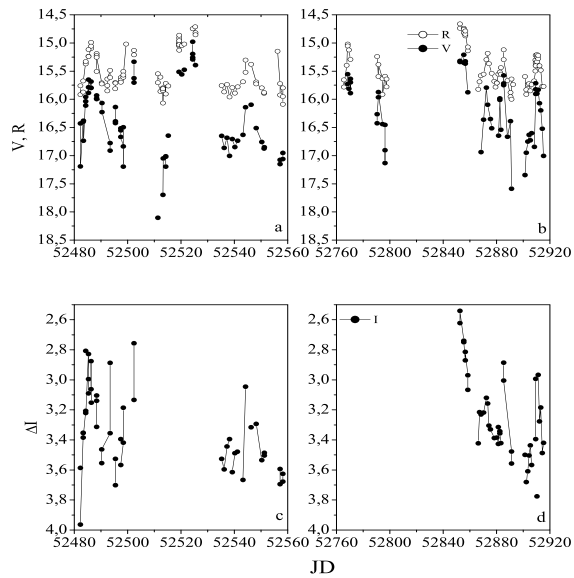

Figure 3: The light curve of V446 Her: a - in the V and R spectral band, b - in the I spectral band during 2002 year; c - in the V and R spectral band, d - in the I spectral band during 2003 year.

4. VRI Light Curves

In Fig.4 the long-term brightness variations of V446 Her are shown. The maximal amplitude was in the V spectral band $\sim 1.8^m$ and the minimal one - in the I $\sim 1^m$. The amplitudes of individual outbursts are variable from cycle to cycle. In the top of the brightest outburst V446 Her reaches $V = 15^m$ likewise ~ 10 years ago (Honeycutt, 1995). It is necessary to note, that we did not take into account the contribution to the luminosity of a neighbor star (Honeycutt et al.,

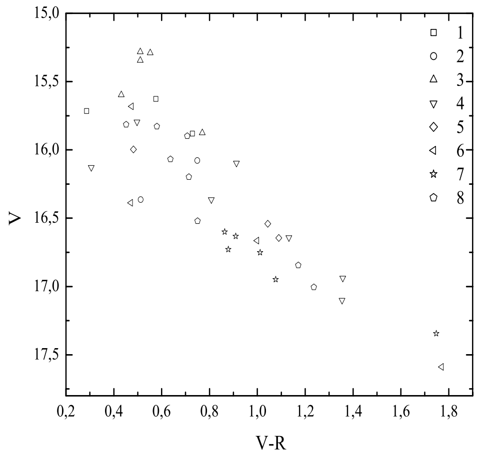

Figure 4: Magnitude - color diagram for 2003 year.

1998b). In 2002 we observed four individual outbursts (or their fragments) and in 2003 - eight such events (or their fragments). The visual inspection of the most dense observations (without of the outburst missing) gives that outbursts occur every ~ 14 days. It is 1.5 times shorter then noted by Honeycutt (1995).

5. Magnitude - color diagram

V446 Her is always bluer when brighter. It is clear visible at the magnitude - color diagram. An example of such diagram for 2003 we presented in Fig.5. There the dependence of color V-R from brightness V is given. All individual outbursts or their fragments are numerated in growing order. One can see a different scattering of individual points along the dependence. The scattering is more in maximum brightness then in minimum that is caused by real change, because they subsequently exeed the errors of measuring. This behaviour could be a consequence of a fact that every individual outburst shows the loop at the magnitude - color diagram . During the ascending branch V-R is greater than during descending one. Also these individual loops do not always coinside with each other.

Such behaviour on the magnitude-color diagram supports idea of the termal instability of accretion disk around white dwarf as a nature of the observing outbursts (Osaki 1996).

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