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Multicolor photometric monitoring of a new WZ Sge-type star in Aquila

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Abstract. Multicolor photometry of a new object PNV J19150199+0719471 during its superoutburst in June and July of 2013 is presented. The detailed light curves for different stages of a superoutburst were obtained and analyzed. The variations of the period and amplitude of superhumps were investigated. The tracks of the variable star on the two-colour diagrams were constructed and described.

Key words: : stars: dwarf novae – stars: individual (PNV J19150199+0719471)

1. Introduction

The WZ Sge stars form a subclass of SU UMa dwarf novae. They have very short orbital periods (typically 80 – 90 minutes), long recurrent time of superoutbursts (decades) and a large amplitude of superoutburst, close to $\sim 8^m$. During a superoutburst there were observed early, ordinary and late superhumps. The nature of physical processes were described by Osaki, Meyer (2002), Lin, Papaloizou (1979), Osaki (1989), Whitehurst (1988), Bisikalo *et al.* (2005), Kaigorodov *et al.* (2006), Smith *et al.* (2007), Smak (2009), Kato *et al.* (2008, 2009, 2013), Zemko & Kato (2013). In the papers of Kato, Pavlenko *et al.* (2009), Chochol *et al.* (2009, 2010, 2012), Pavlenko *et al.* (2010) and Zemko *et al.* (2013) we interpreted the light curves of some WZ Sge-type stars. At present we know $\sim$ 100 WZ Sge-type stars and the investigation of every object is very important for our understanding of physical processes in close binary systems.

2. Observations

The object PNV J19150199+071947 was discovered by K. Itagaki (2013) on May 31, 2013, when it reached 10^m at maximum. Its brightness in quiescence was $\sim 19^m$. We began to observe it on June 2, 2013. We carried out our observations at 2 observatories – in Slovakia (Stará Lesná Observatory of the AISAS) and Ukraine (Crimean Laboratory of the SAI). We obtained $\sim$ 4000 observational

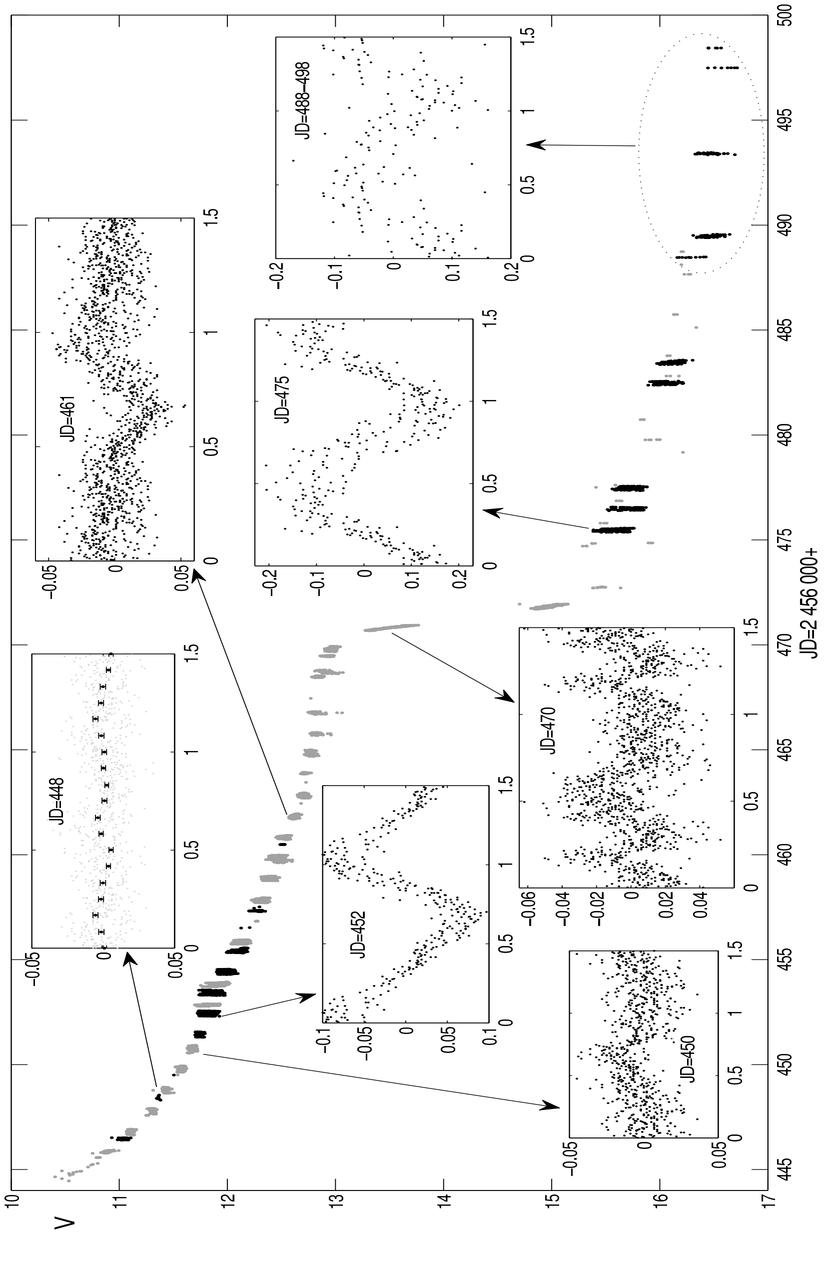

Figure 1. A light curve in the V-band: our observations are plotted as black points (see the text), AAVSO data – as grey points. The superhumps phased light curves of V magnitude differences from the mean light curve after a trend removal are plotted at the embedded frames.

frames in $UBVR_CI_C$-bands. Most of them were obtained in the V-band ($\sim$ 2000 frames) and the R_c-band ($\sim$ 1000 frames). We used different CCD cameras and telescopes with mirror diameters of 50–60 cm.

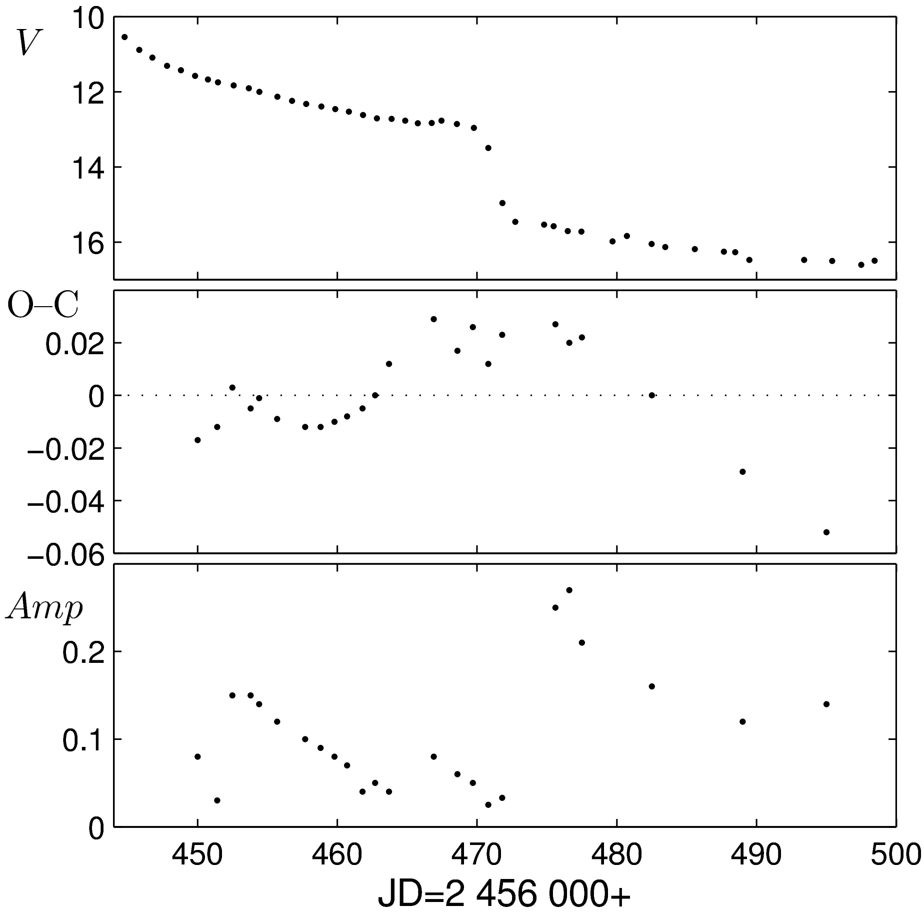

Figure 2. Changes of the $O-C$ residuals (middle) and the amplitude of superhumps (bottom) during the superoutburst of the nova (top).

We included also observations from AAVSO to get the available statistics. The overall light curve in the V band is plotted in Fig. 1. The phased light curves are plotted in embedded frames. In the frame (JD=448) with the data from the fourth night of observations there is seen a double wave per a period. This variability is caused by the presence of "early superhumps" with the period approximately equal to the orbital one. "Early superhumps" are the most distinctive feature of the WZ Sge-type objects and have not been detected in other DNe. In the frame (JD=450), obtained two days later, there is seen the destruction of the double wave. In the third frame (JD=452) we can see the beautiful ordinary superhumps instead of early superhumps. Their amplitude is about 0.15^m and their maxima are shifted to the phase $\varphi = 0.0$. During the fast decline (JD=470) there are some random light variations, but after that we can see the "late superhumps" (JD=475). At that time the amplitude of late superhumps reached $0.^m3$, exceeding the amplitude of the ordinary superhumps during the plateau.

A time series analysis of early, ordinary and late superhumps allows us to determine the mean ephemeris of the superhumps:

$$JD_{\max} = 2456445.220 + 0.058221 \times E, \qquad (1)$$

and to find their period changes. On the $O-C$ diagram (see Fig. 2) we can see the increase of the superhump period from the early to ordinary superhump stage and its decrease from the ordinary to late superhump stage. The diagram shows also the linear increase of the superhump period ($\sim$ parabolic form of $O - C$ residual) and decrease of its amplitude during the plateau at JD=2456452–466.

The period of superhumps did not change significantly around the dramatic fading of the brightness. However, a few days after this event the period suddenly decreased and stabilized. A similar behaviour of $O - C$ residuals were observed in most of the WZ Sge and SU UMa - type stars (Kato *et al.*, 2009, 2013).

Early superhumps show a double–wave per a period with $P_{\rm ear} = 0.0573$ days. For WZ Sge stars $P_{\rm orb} \sim P_{\rm ear}$. So, $\varepsilon = 1 - P_{\rm orb}/P_{\rm sh} = 0.015$. This value is typical for the WZ Sge- and the SU UMa-stars (Chochol *et al.*, 2010).

We found the value of mass ratio $q = M_{rd}/M_{wd} = 0.08$, using equation (5) from Kato *et al.* (2009).

We calculated the period derivatives of superhumps as:

$$P_{\rm dot} = \dot{P}/P \sim 25 \cdot 10^{-5}. \qquad (2)$$

This value shows the rate of change of the period during the plateau stage. For most WZ Sge and SU UMa-stars the value $P_{\rm dot}$ varies from 1 to 15×10^{-5}. But there are some stars with higher values of $P_{\rm dot}$: from 15 to 70×10^{-5} (Kato *et al.*, 2009, 2013). So, this parameter is relativity large for our object.

3. Colour variations

A mean V light curve and changes of colour indices $U-B, B-V, V-Rc, Rc-Ic$ are presented in Fig. 3. During the dramatic fading on the day 28 after the begining of the superoutburst, the UV-excess increased by $0.^m5$, but color indices $B-V, V-R_c$ and especially R_c-I_c changed in the opposite direction (see Fig. 3). Position of the object during the superoutburst in two–colour diagrams are shown in Fig 4(a–c). We estimated $E(B-V)$ as $0.^m1 - 0.^m2$ using the

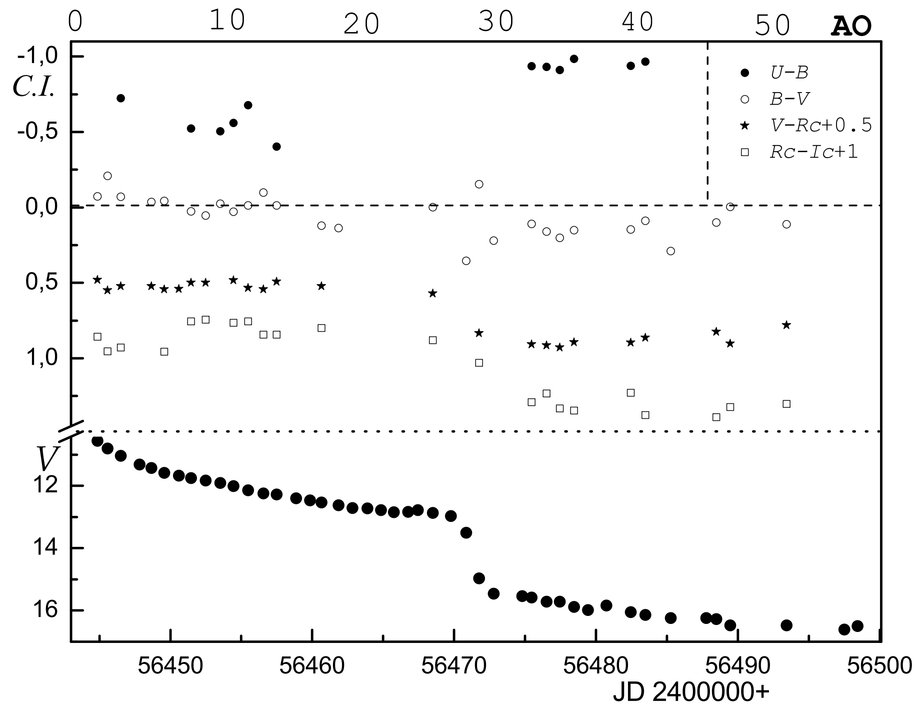

Figure 3. A V light curve and colour indices curves during the superoutburst. The number of days after the begining of superoutburst is indicated on the upper axis.

neighbouring stars. So, the colour temperature during the outburst was close to T ~15000K. In the minima of brightness $T \sim 7000 - 8000K$. Fig. 4d shows a clear dependence of the $V-$magnitude on the $V - R_C$ colour-index.

4. Classification

A new dwarf nova in Aquila belongs to the WZ Sge-type, because:

1) We can detect "early superhumps" which are the unique feature of WZ Sge-type objects.

2) The superoutburst of WZ Sge-type objects are very rare in comparison with other SU UMa dwarf novae. We have no information in any previous outburst of our object.

3) We found the typical change of the superhump period with time. The superhump period excess $\varepsilon = 1 - P_{\rm orb}/P_{\rm sh} = 0.015$ and $q \sim 0.08$.

4) The amplitude of the outburst is close to 9^m.

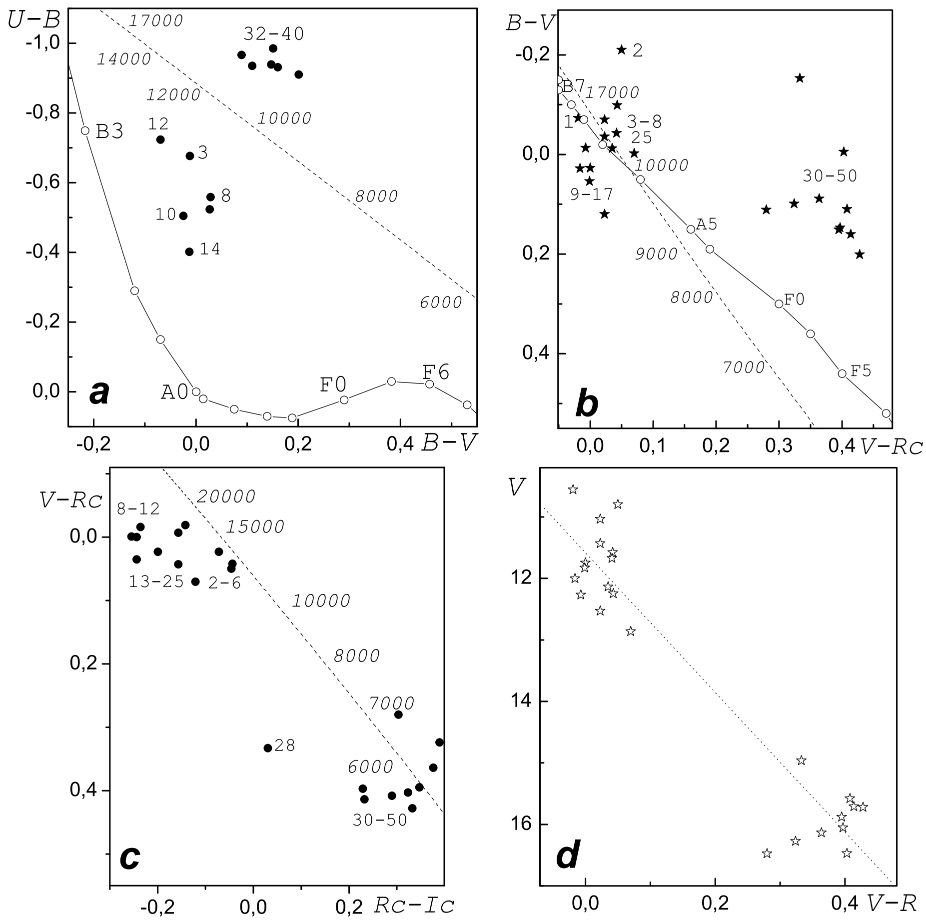

Figure 4. Two-colour (a–c) and colour–magnitude (d) diagrams. The dashed lines denote the black body sequence with a Kelvin scale marked along it. The main sequence is designated by a solid line, the spectral classes are marked. The days after the begining of the superoutburst are designated.

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