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PHOTOMETRIC STUDY OF SELECTED SU UMA-TYPE DWARF NOVAE

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Abstract. In this work we present time-resolved photometry of a few poorly-studied dwarf novae during recent superoutbursts. Observations were made using 60-cm telescope of Sternberg Astronomical Institute in Crimea in October-November 2008 and May-June 2009. Superhumps were detected in the light curves of all novae. The amplitudes and periods of detected light variations were calculated. Superhumps evolution was also followed up for all systems

1. INTRODUCTION

Dwarf novae belong to the class of cataclysmic variables and represent the close binary systems on the late evolutionary stages. They consist of a white dwarf and a red dwarf which fills its Roche lobe and transfers mass to the white dwarf. The gas stream flows from the secondary to the primary white dwarf forming an accretion disk around it. Dwarf novae undergo outburst in semi-periodic intervals of time, when the brightness increases of 3 to 5 magnitudes. For most of them, the faint state (quiescence) is their normal state. During quiescence the disk has a low viscosity and accumulates mass, remaining cool and faint. When the surface density of the disk reaches a critical value, the viscosity increases and mass flow rapidly through the disk to the white dwarf, releasing gravitational energy. The disk became hot and luminous causing the dwarf nova outburst.

There are 3 sub-types of dwarf novae: U Gem, Z Cam, and SU UMa.

- The dwarf novae of U Gem sub-type are the classical dwarf novae with quick brightening of large amplitude (up to 6^m).
- The dwarf novae of Z Cam sub-type show the long standstills at the mean light level on their light curves about one magnitude below maximum.
- The dwarf novae of SU UMa exhibit the special phenomenon, so-called superchamps, on the light curve during a superoutbursts (outbursts of larger amplitude and much longer duration than more frequent normal outburtsts). Superchamps - it is an increase of the system brightness on the small part of the orbital light curve that repeated with the period a few percents longer than

orbital one (amplitudes of superhumps is around $\sim 0^m.1 - 0^m.3$. The orbital periods of this type novae are about 80-180 min.

There is another small sub-group of stars inside of the last group: WZ Sge sub-type dwarf novae, — they show a fast novalike light curve and very long (typically ∼10 years) outburst recurrence time, large amplitude (up to 8^m) and short superhumps period and more small amplitude of superhumps ($\sim 0^m.07$). ER UMa stars - small subgroup of SU UMa stars in which interval between superoutbursts is unusually short. They typically spend a third to a half their time in superoutburst, with supercycle of only 20 to 50 days. The normal outbursts occur in such systems every 4 days.

From consideration of distribution of superhump periods of SU UMa dwarf novae we can see the maximum of the distribution close to $0^d.06$ and monotonous decrease towards longer periods. The origin of superhumps explaines well in frames of tidal-thermal model (Osaki, 1996). As now belived superhumps arise as a result of accretion disk precession which is triggered by gravitational disturbances from the secondary component. These disturbances become most effective when accretion disk mattter moving along an eccentric orbit is in the 3:1 resonance with orbital motion. It was found from observations for many systems that the evolution of superhump period consists of 3 stages: early evolutionary stage with a longer superhump period, middle stage with systematically varying superhump and periods and the last stage with a shorter, stable superhump period.

2. SELECTION OF PROGRAMM STARS

All stars for this study were chosen from VSNET list of dwarf novae undergoing to an superoutburst during the period of our observations. The criteria for our choice were brightness of the object restricted by telescope power and relatively rare superoutbursts. They are:

- KP Cas – SU Uma – type candidate, last confirmed outburst in 1997, outburst ampltude $\sim 7^m$, P_{orb} unknown,
- KV Dra – superoutbursts in 2000, 2002, 2004, 2005, amplitude of superoutburst $\sim 7^m$, P_{orb} unknown,
- MN Dra – discovered by Antipin in 2002, superoutbursts: 2002, 2003, P_{orb} unknown, long $P_{sh} \sim 0^m.104 - 0^m.106$ and short superoutburst cycle $\sim 60^d$
- V 1251 Cyg - WZ Sge – type candidate, discovered by Weber in 1966, only 5 outbursts, all superoutbursts: 1963, 1991, 1994–1995, 1997, amplitude of superoutburst $\sim 8^m.0, P_{orb} = 0^d.07433$,
- UW Tri - WZ Sge-type, discovered by Kurochkin in 1984, superoutbursts: 1995, 2008, amplitude of superoutburst $\sim 8^m.0$, $P_{orb} = 0^d.05334$

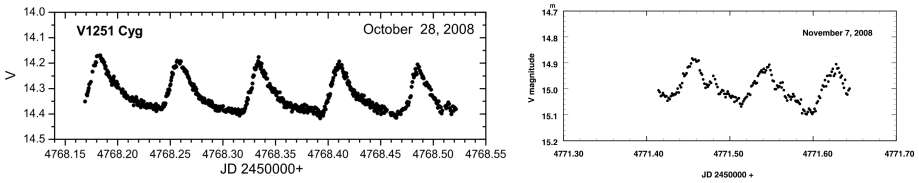

Figure 1: Example of observed light curves with fully developed superhumps for dwarf novae V1251 Cyg (left) and KP Cas (right).

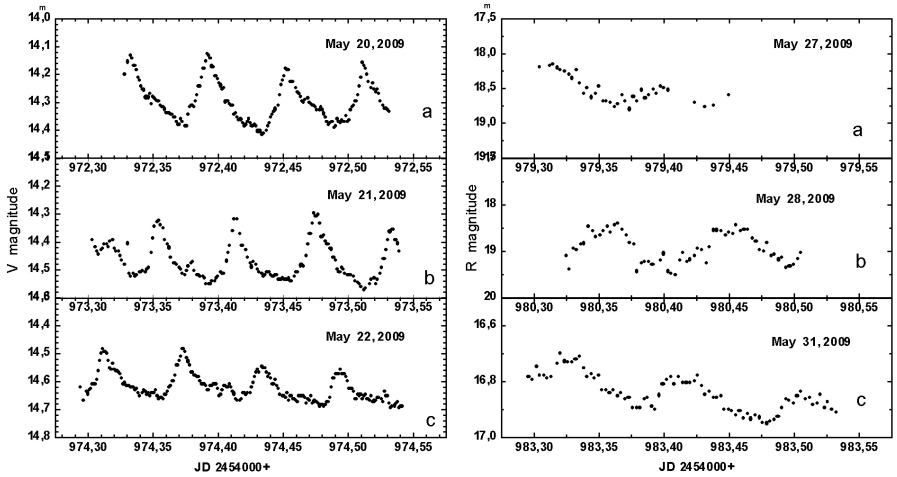

Figure 2: Left: superhumps in daily light curves of KV Dra, amplitude decrease from May 20 to May 22. Right: superhumps in daily light curves of MN Dra: a –decline after outburst, b – minimum, c – normal outburst

3. OBSERVATIONS

CCD observations of program stars were made with Apogee 47 camera (512 x 512mm, pixel size – 13 μm) on the 60-cm telescope of Sternberg Astronomical Crimean Station in V and R bands. The duration of observational sets was from 2 to 5 hours. For two dwarf novae KV Dra and MN Dra observations were partly carried out with CCD Pictor on the 50-cm telescope in R band. The accuracy of CCD observations is $\sim 0^m.5 - 0^m.06$. The reference stars were taken from AAVSO charts. All data were reduced using the program MAXIM DL.

4. RESULTS OF ANALYSIS

Some of the time-resolved light curves of V1251 Cyg, KP Cas, KV Dra and MN Dra displaying superhumps detected for these novae during their recent superoutbursts in autumn 2008 - spring 2009 are shown in Figs. 1 and 2.

V1251 Cyg – an early superhumps appear in the light curve of this nova on October 22. Fully developed superhumps are presented in the light curve of V1251

Cyg on October 26. The amplitude of superhumps became smaller towards the end of our observations ($0^m.15$). The mean superhumps period is $0^d.0757$ and slightly smaller for the last two nights (November 1 and 3).

KP Cas - fully developed superhumps are seen in all light curves with nearly the same amplitude $0^m.17$ and mean period $0^d.0853 \pm 0.001$.

UW Tri - an early superhumps are presented in the light curve on October 28 and 29 whereas in the light curves on November 7 and 8 they already replaced by fully developed superhumps with twice larger amplitude ($\sim 0^m.23$) than at the beginning of outburst. The shape of humps is quite different from superhumps of two other dwarf novae.

KV Dra – amplitude of superhumps decrease from May 20 to May 24, profile from sharp became less steep, profile in R band more shallow than in V band.

MN Dra – our observations were made practically in minimum, but superhumps are also exist.

5. CONCLUSIONS

Summarizing all our finding we could conclude the following:

- Superhumps were detected in the light curves of all dwarf novae.
- The superhump periods which were determined from our data for V1251 Cyg, KV Dra, KP Cas, UW Tri and MN Dra are given below (for V band):
  - V1251 Cyg – $P_{sh} = 0^d.07577 \pm 0.0013$, most accurate;
  - KP Cas – $P_{sh} = 0^d.0853 \pm 0.001$, less accurate because the object was faint;
  - UW Tri – $P_{sh} = 0^d.0537 \pm 0.0003$;
  - KV Dra – $P_{sh} = 0^d.06005 \pm 0.00015$;
  - MN Dra – $P_{sh} = 0^d.09567 \pm 0.00015$.

  Results determined for R band are the same within accuracy limits.
- Superhump periods obtained in this study are in good agreement with periods for other superoutbursts.
- For MN Dra value of period depends on the phase of superoutburst and differs significally.

Acknowledgments

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