ASTRONOMICAL OBSERVATORY AT KOLONICKÉ SEDLO AND ITS RESULTS IN VARIABLE STARS OBSERVING

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ABSTRACT. There is presented a brief report of the actual equipments in the Astronomical Observatory at the Kolonické Sedlo. Description of Vihorlat National Telescope of 1 meter diameter equipped with the two-star high-speed photoelectric photometer and autoguiding system as well as various small telescopes capabilities are included. The results of CCD and PMT observations are presented. The future observational programs are presented as well.

Key words: Instrumentation: PMT photometer, CCD cameras; site testing; telescopes.

1. Introduction

Astronomical Observatory of Odessa National University (AO ONU, Ukraine) and Vihorlat Astronomical Observatory (VAO, Humenne, Slovakia) are cooperatively developing the new Observatory at the Kolonické Sedlo (VAO KS), which is located at north-east of Slovakia, in Vyhorlat mountains, in 40 km from Humenne: latitude=48^o 57'N, longitude=22^o 16'E, alt=465m. Atmospheric conditions are relatively good for the central Europe, in spite of low altitude. About 100 nights per a year are usable for a photometry. The average seeing is about 2.5 arcsec in the best nights.

The observing station at Kolonické Sedlo was launched in **1987**. The observations were done during observing stages and expeditions.

A very important step in the development of the observatory was done in **1999** when the main building of new observatory was finished. During the opening ceremony the Treaty between AO ONU and VAO on the technical assistance and collaboration was signed. According to this treaty the 1 meter telescope manufactured in AO ONU should be installed at the Kolonické Sedlo. Installation has been done in six stages and the telescope was officially inaugurated in **2002**. Thereby, the VAO KS have acquired on the cooperative basis the telescope of the primary mirror 1 m diameter, named the Vihorlat National Telescope (VNT). At present the VNT is the biggest astronomical instrument in Slovakia.

Some small telescopes, Newton 11 inch, Newton 14 inch, etc., were also installed at the observatory and are used for a visual and CCD observations. The experts of AO ONU assisted actively in the adjustment of all instruments.

This set of instruments allow carrying out a wide spectrum of astronomical researches for several observers at once. The VAO KS became a featured astronomical complex having a complete infrastructure with the working rooms and accommodation in its area for about 20-30 persons.

The Observatory is adapted in the high level for educational purposes covering numerous excursions for pupils and students, winter and summer schools for young astronomers from local region and practical exercises for astronomy students of the AO ONU and of the Šafárik University Košice. The principal observing program of the VAO KS is pointed to variable stars researches.

2. Instrumentation

The VNT is placed in 5 m dome (see Fig.2, which motion is synchronized with the motion of the telescope tube. The optical layout of the VNT is shown in Fig. 1 and main characteristics are given in Table 1.

Observational instruments could be installed in two focuses, Cassegrain and Nasmyth. For the work in the Cassegrain focus the optical system of the VNT is corrected by two lenses situated in front of the secondary mirror.

In 2005 the Cassegrain focus of the telescope was equipped by the high speed two-star photometer, which

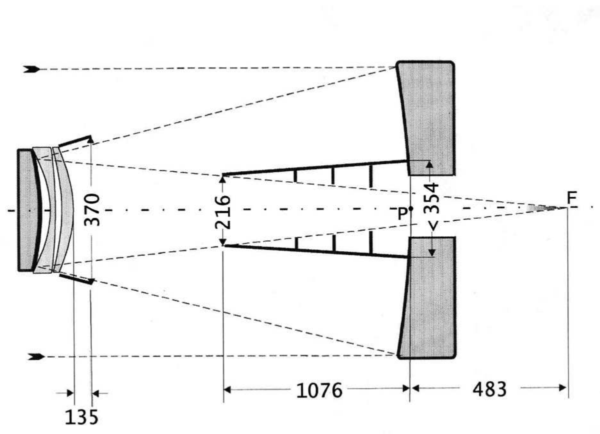

Figure 1: The optical layout of VNT

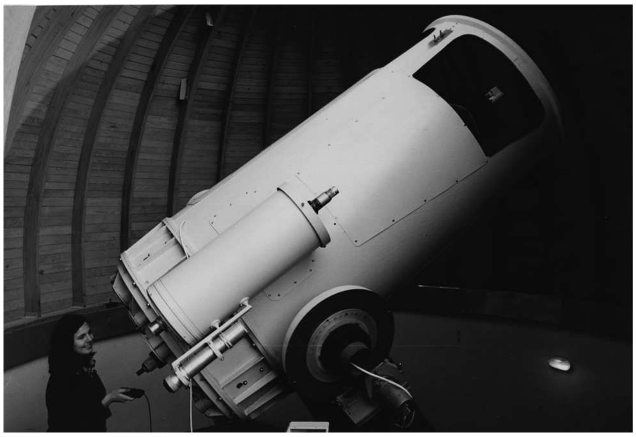

Figure 2: The VNT in the dome

Table 1: Main characteristics of VNT

Optical system	Modified Argunov-Fashchevskyi
Main mirror shape	spherical
Diameter of the main mirror	1 m
Diameter of the secondary mirror	0.3 m
Effective focal length	9 m
Length from the main mirror to secondary	2.03 m
Field of view FOV	0.5 arcmin
FOV diameter in focal plane	78 mm
Scale of FOV	0.043 mm/arcsec

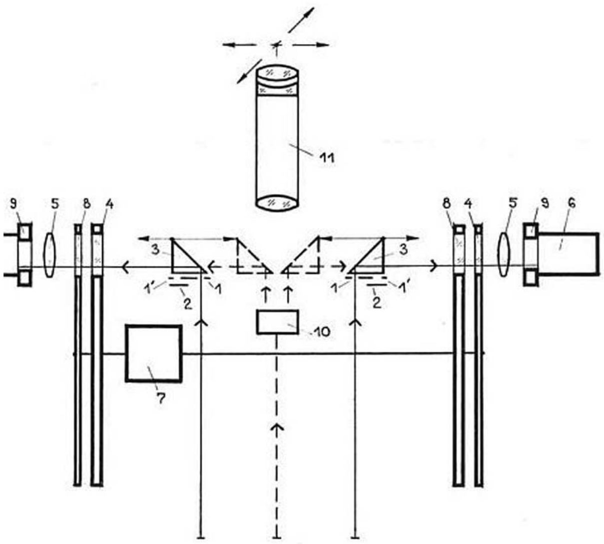

Figure 3: The optical scheme of the PMT two-star photometer

was constructed in AO ONU. The design and observing performance are similar to the previous photometer, which was applied with the Odessa 0.8 m telescope at the Mt. Dushak-Erekdag Observatory in Turkmenistan (Dorokhov & Dorokhova, 1994).
Some improvements were brought into the optical scheme (Fig. 3):
1 - diaphragm (5 different diameters), 1'- diaphragm for sky measurement, 2 - cover automatically uncover diaphragm 1 and 1', 3 - mirrors reflecting the light to the photomultiplier, 4 - filter wheel, 5 - Fabry lens, 6 - photomultiplier, 7 - simultaneous turning of filter wheels, 8 - neutral filter, 9 - photomultiplier cooling, 10- mechanical displacement of mirrors 3, 11- microscope.

The main problem for the multichannel PMT-photometers is the accurate verification of the channels' sensitivity (Breger & Handler, 1993). For this reason there are provided calibrations with using the artificial emission sources (Dorokhov, 1999).

The Nasmyth focus is preparing now for CCD multicolor photometry and/or for spectroscopy. The switching from the Cassegrain focus detector to the Nasmyth focus one could be done by insertion of the flat mirror located inside the telescope tube.

Since the telescope and photometer were manufactured recently they both required the detail investigations and improvements. Specially, there were many telescope's problems: a right installation, an optic alignment, an adjustment of the hourly motion, etc. Particularly important for the time series of observations there is clearing the telescope hourly motion from the periodic components which are arisen due to an irregular rotation of the driving gears. There was not succeed completely removing this problem. Thus the telescope is needed in the automatic guiding.

The automatic guiding of the telescope was developed by Martin Myslivec by using Mintron CCD camera CCD initially through the 30 cm Ritchey-Chretien pointer.

3. The test of two-stars photoelectric photometer

Initially, the photometer was used for the VNT testing. At first we selected the pairs of constant stars of the same magnitudes and colors frequently in open clusters. On such observations we revealed that the pointer changed a little its direction in respect to the main telescopes as a result of bents during the movement of the VNT. Then the stars left the diaphragms sometimes during a night. The problem was removed when CCD-autoguide was directly installed on the photometer's eyepiece.

After that we examined the dual-channel advantages in a windy cloudy night. In Fig. 4 there are shown the simultaneous observations of pair of the stars:
HD161677 (V: 7.14, B-V:-0.02, sp:B6V);
HD161603 (V: 7.34, B-V:-0.00, sp:B5V)
in Johnson's B filter with 10 sec integration time. It is seen that even when accounts in each channel are decreased on about 100% the average line on the bottom panel have deviations less than 3%.

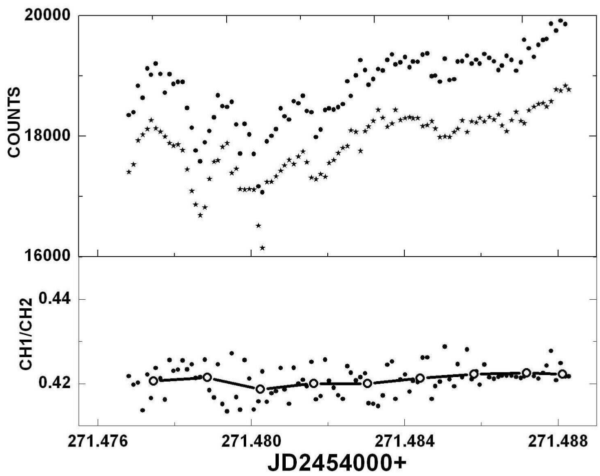

Figure 4: Simultaneous measurements of constant stars HD161677 and HD161603 with the two-star photometer in the windy cloudy night. There are presented: the data of each channel in the top panel and the ratio of these data in the bottom panel. The solid line with empty circles indicates the 2 min. averages of the data.

For achieving a high photometric quality we followed the standards and techniques of the global asteroseismology networks: DSN, Delta Scuti Network (see, e.g., Breger & Handler, 1993) and WET, Whole Earth Telescope((Nather et al., 1990; Kalytis et al., 1993). For accounting an atmospheric influence we focused on the

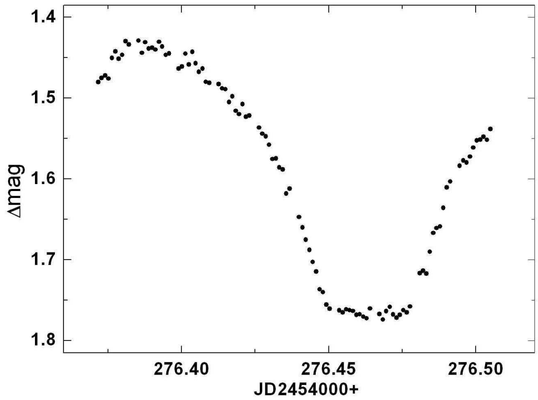

Figure 5: Light curve of EW/KW star TZ Boo obtained with the VNT + PMT photometer + V filter in 24.06.2007

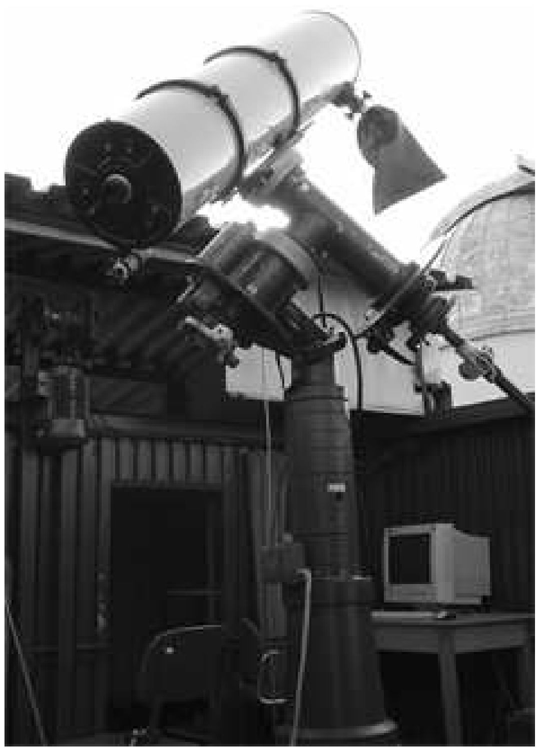

Figure 6: One of the small telescope, "Pupava" of 280 mm mirror diameter.

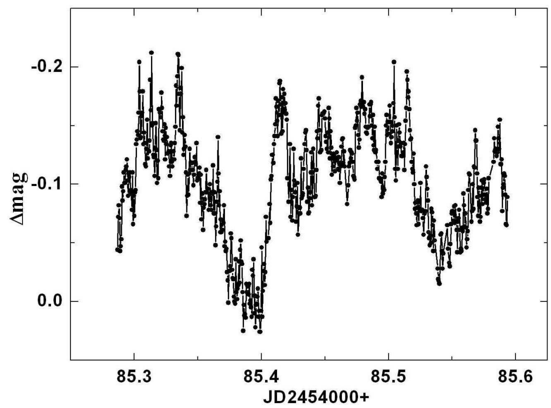

Figure 7: The flickering and irregular variations of the brightness at the minutes' time scale of cataclysmic variable star GK Per obtained in 15.12.2006 with Pointer + SBIG ST-9XE camera.

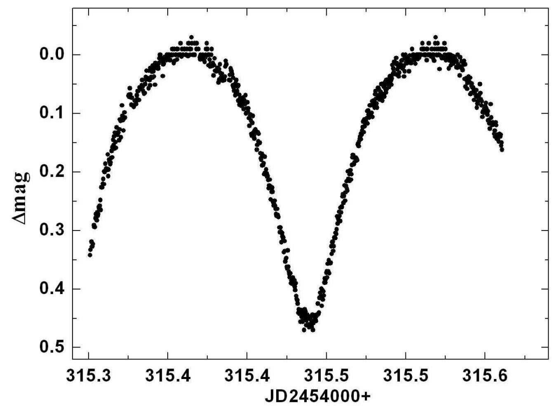

Figure 8: The minimun of W UMa type star CW Cas observed with Hugo+ Meade DSI Pro+V filter in 02.08.2007

factors described in the paper of Pakstiene & Solheim (2003).

In June-July 2007 we tested the system of VNT-photometer on the recently discovered low amplitudes Lambda Boo star V2314 Oph (Kim et al., 2007) in the frames of the multi-site campaign. These observations showed the accuracy of the continuous photometry sometimes more then $0.^m01$. Nevertheless, the VAO KS data are coincident in a phase with the light curve obtained in the Sierra-Nevada Observatory (Martin Ruiz, 2007).

We detected that the photomultiplier of the channel 2 has a low sensitivity and we replaced it by another FEU79. After that the the accuracy was improved till $0.^m002$-$0.^m003$ under the good atmospheric transparency.

Now the instrument is regularly observing the program stars. The eclipse of well known EW/KW binary TZ Boo (V= 10.41, Sp G2V) is presented in Fig. 5.

4. CCD photometry at VAO KS

The CCD photometry was also helpful as for an examination of the VNT as well the PMT two-star photometer. We registered the deflections of the images at both coordinates, thus cleared the reasons of the periodic deflections of the VNT tube. We also tested the photometer's sensitivity when the target star pass through the diaphragm. Simultaneous observations of the same object with the VNT+PMT photometer and with some of other telescopes+CCD camera gave an opportunity excluding the possible bugs in programmes and/or construction.

As it was mentioned already, some small telescopes work in the Observatory. Every of them has own task and own name, in according with its character. One is shown in Fig. 6. It was supplied by the name "Pupava" ("dandelion") to for the cheerful yellow colour. The Meade DSI Pro cameras with Sony ExView HAD Monochrome CCD Sensor with 510 x 492 pixels are usually used with these telescopes.

In Table 2 we give descriptions of these telescopes including the pointer of the VNT.

CCD observations were started after arrival of the permanent observer (PAD) to the VAO KS in March 2006. First CCD measurement was made on 07 April 2006 with the camera Meade DSI Pro mounted on Lichtenckencker telescope of 150 mm. Actually, 3 CCD cameras worked with Hugo, Púpava telescopes and 400 mm telephoto lense. The observations were acquired mainly during the summer campaigns and astronomical practical exercises for young astronomers. During 197 observational nights from 07 April to 31 July 2007 we have obtained 338 light curves of 87 stars. We have collected 141 times of minima in 53 eclipsing binaries. Totally, we have acquired 101737 images.

A large data base of 2581 measurements in 10 nights of 2006-07 was acquired with SBIG ST-9XE for GK Per, symbiotic binary: sdBE + K2IVp, the nova of 1901.

This very interesting cataclismic variable has varies types of activity: rapid irregular variations Δm $0^m.1$ in several minutes), irregular fluctuations from night to night Δm $0^m.3$), slow irregular variations and bursts. Flickering and variations of the brightness at the minutes' time scale are presented in Fig.7.

5. Observing program of VAO KS

So, the main observational program is focused on the researches of pulsating stars, eclipsing binaries, specially, cataclysmic and symbiotic stars.

Initially, there were visual estimates of the minima times of eclipsing binaries. Afterwards, this directions were transformed to the CCD photometry of contact systems of the W UMa type, with ellipsoidal components of F0-K spectral type. Before mentioned CW Cas and TZ Boo are related to this type of variability. For these systems is typical that depths of minima are vary significantly from year to year, sometimes Min II become deeper than Min I. The light curves' shape and parameters are also usually variable. We are seeking to acquire such amount of light curves which make possible the unambiguous theoretical conclusions concerning the processes in these key objects.

We also take part in the campaigns of global photometry on Nova-like stars V603 Aql and V Sge. The basic work was made for superoutbursts' observations of SU UMa type stars IY UMa, MR UMa, V419 Lyr, CI UMa, RXSJ053234, VY Aqr, V844 Her. Till present time by using these CCD-observations two papers have published in OEJV (Parimucha& Dubovsky, 2006), one in IBVS (Parimucha et al. 2007) and a few papers are in preparation.

Later, with adoption of the PMT photometry, the pulsating variables were attached and are dynamically investigated.

The observational activity is mainly done according to the international cooperation of four institutions:

Vihorlat Astronomical Observatory, Humenné

Astronomical Observatory of Odessa National University, Odessa

Astronomical Institute of Slovak Academy of Science, T. Lomnica

Institute of Physics, Šafárik University, Košice.
The future development of observing activities is scheduled in the Table 3.

6. Conclusion

Observing strategy (see Table 4) is arranged within the international seminar KOLOS, which is regularly holds in early December from 2003. The experts of different institutions and different directions of the science, engineers, amateurs and students have an opportunity for a discussion, uniting their efforts for a development of astronomy in Slovakia and, particularly, for an enhancement of the research scope in the VAO KS .

More detailed description of the VAO KS, as well as the astronomical tools are available at the Observatory website:

http://www.astrokolonica.sk.

Acknowledgements: The work was supported by the Ukrainian MON grant No M/153-2006 and the Bilatelar APVV grant SK-UK-01006, as also the Grant of the Slovak Research and Development Agency LPP-0049-06, VEGA grant 7011 and grant of the Šafárik University VVGS 9/07-08 and The National Scholarship Programme of the Slovak Republic.

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Table 2: Characteristics of some small telescopes in the VAO KS

	Pointer	***Chermelin***	***Hugo***	***Pupava***
Optical system	Ritchey-Chretien	Newton	Newton	Newton / Cassegrain
Diameter [mm]	300	300	265	280
Focal lenghth [mm]	2400	1500	1360	1500/3500
Mount	Fork equatorial	Alt/Az	German equatorial	German equatorial
Constructor (telescope/mount)	AO Odessa	AO Odessa / CVUT Prague	AO Odessa / Uniwersal Poland	Uniwersal Poland / AO Odessa
Exploitation	Autoguiding of VNT	Automated monitoring of cataclysmic variable stars (future)	CCD photometry times of minima of eclipsing variable stars	Time series color CCD photometry of cataclysmic variable stars

Table 3: Observing program of the VAO KS

Observed objects	***Equipment***	***Actual situation***
Astroseismology, Flickering in Cvs, fine effects on light curves of EBs	1 meter VNT + photometer	Testing observations with photometer
Four color photometry of CVs (Polars)	100 cm VNT + CCD	Nasmyth focus of VNT (in preparation)
Monitoring of faint CVs	30 cm Chermelin + CCD	In preparation of alt-azimuthal mount
High speed photometry of CVs	28 cm Púpava + CCD	Observing
Times of minima of EBs with strange O-C	26,5 cm Hugo + CCD	Observing
Times of minima of bright EBs	400 mm telephoto lens + CCD	Observing
Monitoring of bright CVs	Visually with Newton 30 cm	Until now using 30 cm Chermelin telescope
Semi regular variables, Be stars, Symbiotic variables, EBs without known elements	Newton 30cm visually, Somet and DB binocular	Observing

Table 4: Observing program for the VNT, according the KOLOS-2006

Object type	***Observational purposes***	***Targets***	***Researchers***
Interacting binaries	Flickering in symbiotic binaries	V694 Mon, T CrB, RS Oph, V404 Cyg, V627 Cas	Hric, Parimucha, Dobrotka
Interacting binaries	Pulsations of cold components	IU Per, TW Dra	Hric, Zejda
Chemically peculiar stars	Multicolor photometry	AR Aur, V624 Her, HD 37776	Zverko, Žižňovský, Mikulášek
Algol type EB	Rotation velocity	BW Boo	Glazunova
Pulsating variables	Asteroseismology	V2314 Oph, VW Ari	Dorokhova
Be stars, Novalike, X ray	Outbursts, rapid variations	V725 Tau, X Per, V831 Cas, V635 Cas, TT Ari	Dorokhova, Dorokhov
Eclipsing binaries	The shape of light curve, fine effects	AK Her, RV Oph, V729 Cyg, EE Peg, BM Ori, AW UMa, BH UMa, V577 Oph, KP And, FF Cnc	Kudzej