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INTRODUCTION

The Variable Star and Exoplanet Section of the Czech Astronomical Society organized traditional autumn conference on research and news in the field of variable stars. The conference was held in a comfortable space of Ostrava Planetarium. In addition to the many contributions that were presented on site, we had the opportunity to hear lectures of invited speakers from abroad via Internet transmission. All presented contributions can be viewed on our YouTube channel.

I would like to thank all conference participants, and all speakers for their presented contributions. I also would like to thank the Director of Ostrava Planetarium Mrs. Markova and her colleagues for providing venues for conferences and helpfulness to our needs.

Kateřina Hoňková

president of Variable Star and Exoplanet

Section of Czech Astronomical Society

Valašské Meziříčí, March 2020

NOTES

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Modeling of GX Lacertae

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Abstract: GX Lacertae is a long period eclipsing binary system. It was observed at Masaryk University Observatory in Brno in the passbands B, V, and R. The phase curve, which was created from obtained data, was almost completed. The model of this system was calculated with the PHOEBE program. The results of these calculations can be interpreted as initial parameters that need to be refined by further measurements.

Introduction

GX Lac (GSC 03992-02090, HD 240055) is an eclipsing Algol type binary star. It is located on coordinates $\alpha_{2000} = 22^h46^m16^s{:}78$, $\delta_{2000} = +56°51'07''.74$ near to other eclipsing systems CO Lac and V474 Lac. Although it is a relatively bright object (V = 10.1 mag), there is only a little information about it.

Observations and analysis

The observations took place at Masaryk University Observatory in Brno. GX Lac was successfully observed for 13 nights in 2018. Photometric data were obtained in Johnson filters *B*, *V*, and *R* using Newton telescope 600/2780 and CCD camera G4-16000. Additional data were adopted from observations of Reinhold Auer, Miloslav Zejda, and ASAS-SN.

The acquired measurements were analyzed using MuniWin 2.1 (Motl, 2010) and the phase light curve (Figure 2) was created with parameters P = 6.3552417 days and M_0(HJD) = 2 452 504.3675 days. Despite the comparatively long period of GX Lac, the phase curve was almost complete. In parts of the curve without eclipses, magnitude remains constant.

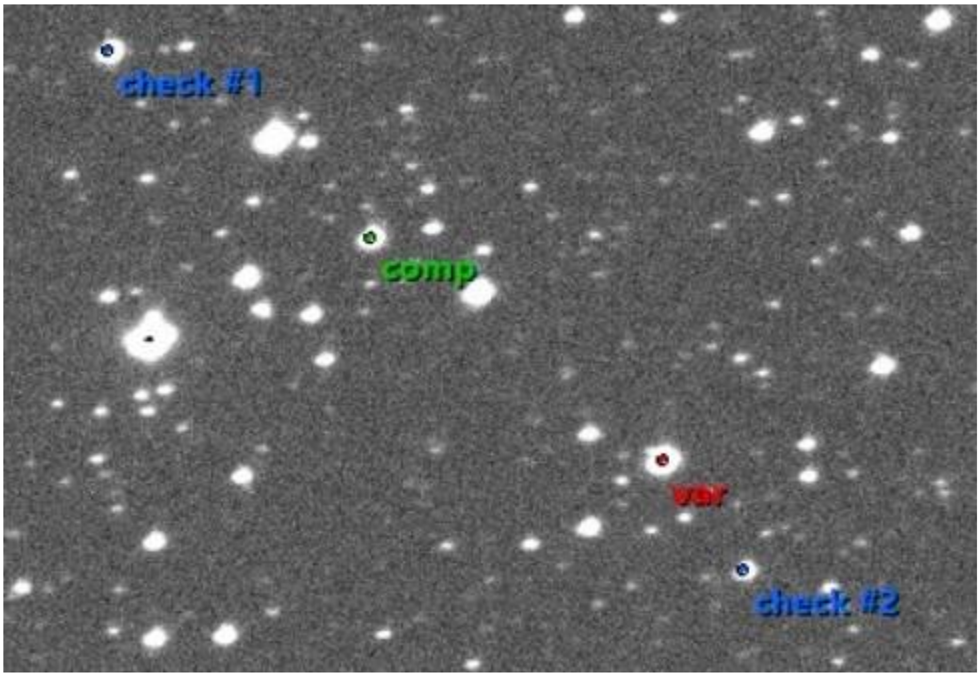

Figure 1: Map of variable, comparison and check stars

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Model

The analysis of the light curve was made with PHOEBE software, version 0.32 (Prša & Zwitter, 2005), which is based on the WD code (Wilson & Devinney, 1971). For the effective temperature of the primary component (T_1), the value was estimated at 12 500 K and was fixed during the fitting process. Based on the shape of the light curve, the binary system was considered to be detached with a circular trajectory for both stars.

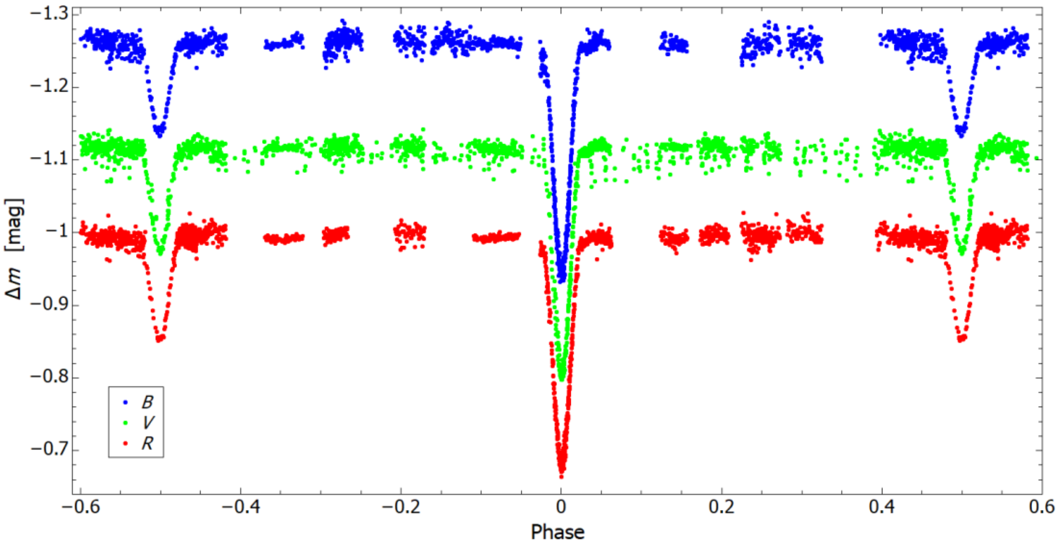

Figure 2: The phase curve of GX Lac

By calculation in PHEOBE, it was possible to derive mass ratio $q = \frac{M_2}{M_1} \approx 0.5$, radii ratio $\frac{R_1}{R_2} \approx 1.8$, inclination angle $i \approx 87°$, and the effective temperature of the secondary star $T_2 \approx 8800\,K$. It is complicated to obtain trustworthy uncertainties for these parameters because all the calculations are based on only photometric observations. The uncertainty of T_2 can be more than 500 K. Figure 3 depicts how the final model corresponds to measurements. Despite the good agreement with observations, the model is not sufficiently consistent. To refine the model it is necessary to obtain spectroscopic data.

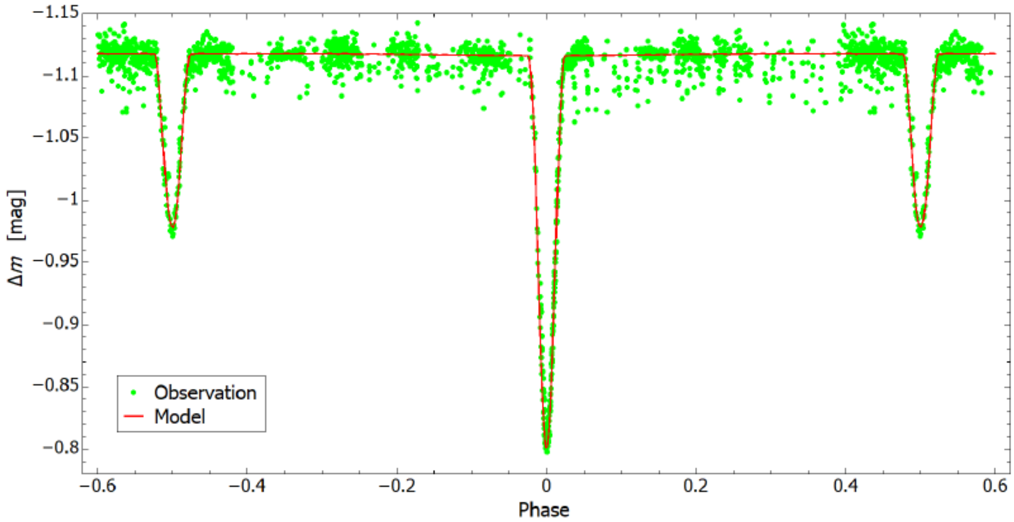

Figure 3: The comparison of model and observations of GX Lac.

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Conclusions

GX Lac was observed in Brno in 2018. Its light curve was analyzed in the PHOEBE program. The resulting model is not completely precise. However, it gives an initial estimation of system parameters. Significantly more photometric data and spectroscopic measurements are required for a sufficiently accurate model.

Acknowledgement

The author would like to thank Reinhold Auer, Miloslav Zejda, and ASAS-SN project for obtained data.

References

Motl, D., 2010, MuniWin V2.1, http://c-munipack.sourceforge.net

Prša, A., & Zwitter, T. (2005). A computational guide to physics of eclipsing binaries. i. demonstrations and perspectives. The Astrophysical Journal, 628 (1), 426, 2005ApJ...628..426P

Wilson, R. E., & Devinney, E. J. (1971). Realization of accurate close-binary light curves: Application to MR Cygni. The Astrophysical Journal, 166, 605, 1971ApJ...166..605W

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Cataclysmic variable CzeV404 Her

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Abstract: CzeV404 Her is a cataclysmic variable star of SU UMa type which was discovered in 2013. We present an analysis of the structure of this system, which was based on light curve modelling of eclipses and Doppler tomography applied to spectroscopic observations. We also present analysis of the outburst and superoutburst periodicity of this cataclysmic variable and predict an occurrence of a superoutburst around 24th of May, 2020.

Introduction

CzeV404 Her (2MASS J18300176+1233462) is a cataclysmic variable (CV) of SU UMa type, which was discovered by Cagaš & Cagaš (2014). CV of SU UMa type consist of a white dwarf (WD) and a less massive late-type star as a secondary, the orbital period is usually below 2.5 hours. An important component of the SU UMa CVs is an accretion disk around the WD, which is formed by matter transferred from secondary onto the WD. The accretion disk can undergo a thermally unstable phases, which lead to brightenings of the disk called outbursts. SU UMa type CVs manifest two types of outbursts – normal outburst, which lasts usually few days, and superoutbursts, which are longer (~ 14 days) and brighter than normal outbursts and occur less frequently. A detailed description of CVs was given e.g. by Warner (1995).

CzeV404 Her was studied by Cagaš & Cagaš (2014) and Bąkowska et al. (2014), each paper reports observations of one superoutburst in addition to several normal outbursts. Both Cagaš & Cagaš (2014) and Bąkowska et al. (2014) estimated the mass ratio to be $q \approx 0.3$, which is inconsistent with the thermal-tidal instability model of superoutbursts by Osaki (1989), which assumes smaller mass ratio $q < 0.25$. The orbital period of the system is 2.35 hours, which puts the system inside of the period gap of CVs, which is a range of orbital period underpopulated by the observed CVs.

Observations

For the study of CzeV404 Her photometric and spectroscopic data were used. Photometric observations were carried out at the Ondřejov Observatory in Czech Republic, La Silla Observatory in Chile and San Pedro Mártir Observatory in Mexico. Observations at the Ondřejov Observatory were obtained in years 2014 – 2019 using 65cm telescope. Observations were carried out mostly in clear filter. In year 2019 several observations in V filter were carried out in order to monitor long-time variations of the system. Examples of light curves obtained at the Ondřejov Observatory are shown in Figure 1. Observation at La Silla Observatory took place in March 2019, 1.54m telescope and R photometric filter were used. Observations at San Pedro Mártir observatory were obtained in April and July 2019 and were carried out using 84cm telescope equipped with a V photometric filter.

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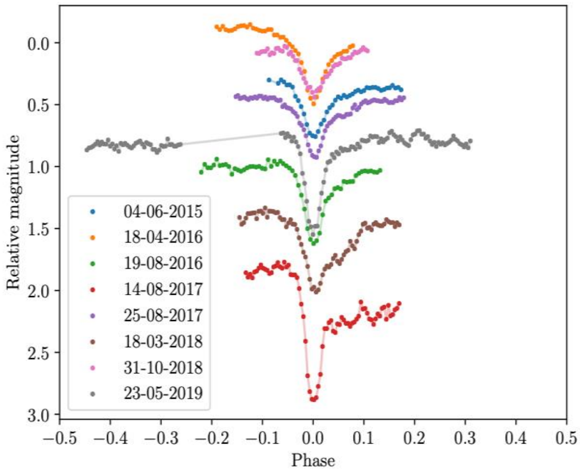

Figure 1: Examples of light curves obtained at the Ondřejov Observatory with a clear filter. All changes of the out-of-eclipse brightness are caused by the changes of brightness of the accretion disc.

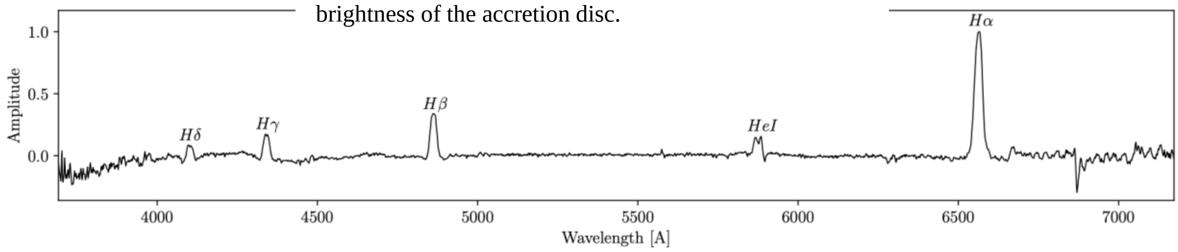

Figure 2: Examples of light curves obtained at the Ondřejov Observatory with a clear filter. All changes of the out-of-eclipse brightness are caused by the changes of brightness of the accretion disc.

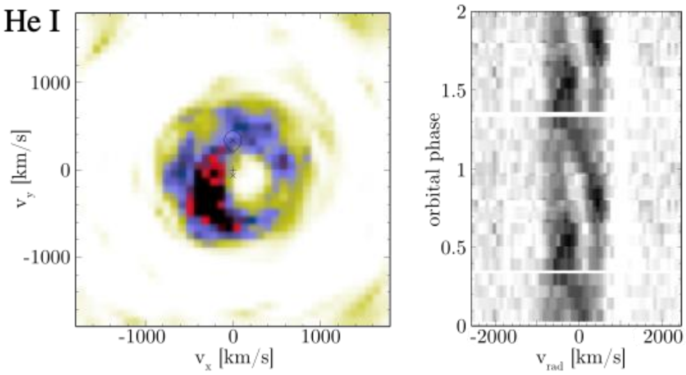

Figure 3: Doppler map based on the HeI (5876 Å) line (left) and trailed spectra (right).

Simultaneous spectroscopic observations were obtained using 2.12m telescope and Boller & Chivens spectrograph. Spectroscopic observations were carried out during five nights, during three nights medium resolution spectra were obtained and during two night high resolution spectra centred on Hα line were obtained. During each night a series of spectra covering the whole orbital period were acquired. An example of an average plot of the spectra obtained during one night in the medium resolution is shown in Figure 2.

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For the analysis additional archival data were used, namely photometric observations obtained at BSObservatory, Czech Republic[1], and photometric data in V and g photometric filters from the ASAS-SN Photometry Database[2]. For description of the ASAS-SN project see Shappee et al. (2014), Kochanek et al. (2017) and Jayasinghe et al. (2019).

Data analysis

Photometric data obtained at San Pedro Mártir Observatory were used for light curve modelling using CVLAB code described by Zharikov et al. (2013). By light curve modelling parameters of the systems could be determined. All available photometric observations were used for the study of periodicity of outbursts and superoutbursts, a period of superoutburst occurrence was established and future times of superoutburst occurrences were predicted. The firsts observable superoutburst in year 2020 is predicted to occur around 24th of May.

Spectroscopic observations were used for the study of the accretion disc structure using Doppler photometry. For the computation of the Doppler maps program DOPMAP[3] developed by Spruit (1998) was used, for each map spectra from a single night were used. An example of a Doppler map based on the He I line of wavelength 5876 Å which was observed on the 8th April, 2019 is shown in Figure 3.

Results

We have improved the ephemeris of the object based on the published and our new photometric eclipse timings to obtain

$$\mathrm{HJD} = 24\,58423.21138(10) + 0^{\mathrm{d}}.09802123(7)\cdot E.$$

By the light-curve modelling we derived $i = 78°$. Assuming this value of inclination, other parameters derived by the light-curve modelling are $K_1 = 66$ km/s, $K_2 = 347$ km/s, $M_1 = 0.6\ M_\odot$, $M_2 = 0.1\ M_\odot$ and $a = 0.8\ R_\odot$. The mass ratio derived by the light curve modelling is $q = 0.19$, which is smaller than the values estimated by Cagaš & Cagaš (2014) and Bąkowska et al. (2014) and is in agreement with the assumption $q < 0.25$ made by Osaki (1989). Based on the Doppler tomography we confirm that CzeV404 Her is a dwarf nova of the SU UMa type system. A paper covering findings of this study in detail is in preparation.

References

Bąkowska, K., Olech, A., Pospieszyński, R., Martinelli, F., & Marciniak, A. 2014, Acta Astron., 64, 337, 2014AcA....64..337B

Cagaš, P. & Cagaš, P. 2014, Information Bulletin on Variable Stars, 6097, 1, 2014IBVS.6097....1C

Jayasinghe, T., Stanek, K. Z., Kochanek, C. S., et al. 2019, MNRAS, 485, 961, 2019MNRAS.485..961J

Kochanek, C. S., Shappee, B. J., Stanek, K. Z., et al. 2017, PASP, 129, 104502, 2017PASP..129j4502K

Osaki, Y. 1989, PASJ, 41, 1005, 1989PASJ...41.1005O

Shappee, B. J., Prieto, J. L., Grupe, D., et al. 2014, ApJ, 788, 48, 2014ApJ...788...48S

Spruit, H. C. 1998, arXiv e-prints, astro, 1998astro.ph..6141S

Warner, B. 1995, Cataclysmic Variable Stars, Cambridge Astrophysics (Cambridge University Press), 1995CAS....28.....W

Zharikov, S., Tovmassian, G., Aviles, A., et al. 2013, A&A, 549, A77, 2013A&A...549A..77Z

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[1]) Data can be downloaded at http://var2.astro.cz.

[2]) Database can be accessed at https://asas-sn.osu.edu/.

[3]) Version 2.3.1 of the code was used, the code is available at https://wwwmpa.mpa- garching.mpg.de/~henk.

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On the spin period variability in intermediate polars

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Abstract: We conduct the long-term research of group of interactive binary stars with the different degree of influence of the magnetic field on their structure and evolution using CCD photometry. In this paper we present a review of recent results obtained by our team. We confirm the strong negative superhump variations in the intermediate polar RX J2133.7+5107 and improved a characteristic time of white dwarf spin-up in this system. We found a spin period variability in the V2306 Cygni system. We have investigated the periodic modulation of the spin phases with the orbital phase in MU Camelopardalis. We can propose simple explanation as the influence of orbital sidebands in the periodic signal produced by intermediate polar.

Introduction

Intermediate polars, often called DQ Her type stars, are close binary systems consisting of a magnetic white dwarf and a red dwarf filling the Roche lobe. The gravity of the primary component leads to capture of matter from the secondary component near the inner Lagrangian point. Due to strong magnetic field of the primary, the flow of matter has a complicated structure – the stream, disk and accretion column. The accretion columns in such systems are often the brightest sources of polarized radiation in a wide spectral range.

The light curve of intermediate polars is usually a superposition of periodic spin and orbital variability, aperiodic processes like flickering or outbursts, sometimes changes between high and low luminosity states (see Breus et al., 2017 and Andronov, Mishevskiy & Breus, 2017).

The spin variability is caused by the rotation of the white dwarf with one or two accretion columns. Typical range of periods is from few to dozens of minutes. In different systems we may see one-hump or two-hump shape of the spin variability.

The orbital variability is caused by the rotation of the system. During one period, we see the components, an accretion disk and a hot spot on it at different angles. The orbital periods of intermediate polars are usually about 3-7 hours (see Patterson, 1994, Warner 2003).

Intermediate polars often exhibit spin-up or spin-down of the white dwarf rotation, while some systems exhibit more complex behaviour of the spin period change. We monitor changes of the spin periods of white dwarfs in a sample of close binary systems to study interaction of the magnetic field and accretion processes as well as evolution of intermediate polars. Our previous research included V1323 Her (Andronov et al., 2011), FO Aqr (Breus et al., 2012), EX Hya (Andronov & Breus, 2013), V709 Cas (Hric et al., 2014), V405 Aur (Breus et al., 2013) and more recent results on other objects of this class (Breus et al., 2014, Petrik et al., 2015, Breus et al., 2019).

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Observations

High accuracy and long time series of CCD photometry allow us to investigate fine effects on complex light curves and study the variations of the white dwarf rotation that cause period variations in intermediate polars. We regularly obtain data using Vihorlat National Telescope at the Astronomical Observatory on Kolonica Saddle, Slovakia (1 meter); 60 cm Zeiss Cassegrain telescope at the Observatory and Planetarium of M. R. Stefanik in Hlohovec, Slovakia; 50 cm Zeiss and 40 cm Maksutow telescopes of Fort Skala Astronomical Observatory of the Jagiellonian University in Krakow, Poland. Sometimes we obtain time series from other telescopes in Ukraine, Korea, Hungary, and Slovakia. Usually we use long CCD time series from AAVSO international database and data obtained by such projects like ASAS, SuperWASP and others in our research.

The reduction usually consists of trivial calibration of scientific images for bias, dark and flatfield and extraction of instrumental magnitudes. It was carried out with the Muniwin (by D. Motl) and CoLiTecVS (Kudzej et al., 2019) software packages. The final light curves were obtained using the multiple comparison stars method described by Kim, Andronov & Jeon (2004) and implemented in Multi-Column View (Andronov & Baklanov, 2004). Barycentric correction is applied for all geocentric Julian dates.

Period analysis and determination of extrema timings were carried out using Variable Stars Calculator (Breus, 2003 and 2007) and MCV. The (O-C) analysis was performed to study the variability of the orbital and spin periods of the systems. To increase the accuracy, we avoided using individual extrema. For some data sets we determined one extremum per night of observations, for other we joined few consequent nights. The method has been previously widely used for approximation of observations of intermediate polars (Andronov & Breus, 2013) and its last modifications including multiple iterations of (O-C) analysis for improvement of the value of the period of the system was recently described by Breus, Petrik & Zola (2019).

We use the dependence of phase on the Julian date or the integer cycle number as an (O-C) diagram. The linear trend on this diagram argues for the necessary period correction, the parabolic trend shows a presence of period changes. More complicated changes are frequently observable: spin-down may change to spin-up and back.

Discovery of the spin period variations in V2306 Cygni

The pulsating X-ray source 1WGAJ1958.2+3232 was discovered by Israel et al. (1998). Zharikov et al. (2002) and Norton et al. (2002) reported two different values of the orbital period that were 1-day aliases of each other and later agreed the value of $0.^{d}181195 \pm 0.^{d}000339$ obtained using joint data set. We started our photometric monitoring of this object in 2009. Using dozen of own runs and 14 CCD time series from the AAVSO data archive, Breus et al. (2014) analyzed the periodogram and discussed different prominent peaks, including the orbital period and it's aliases. We found the new possible period of about 2.01 days that had corresponding peak at the large range periodogram and as a beat period.

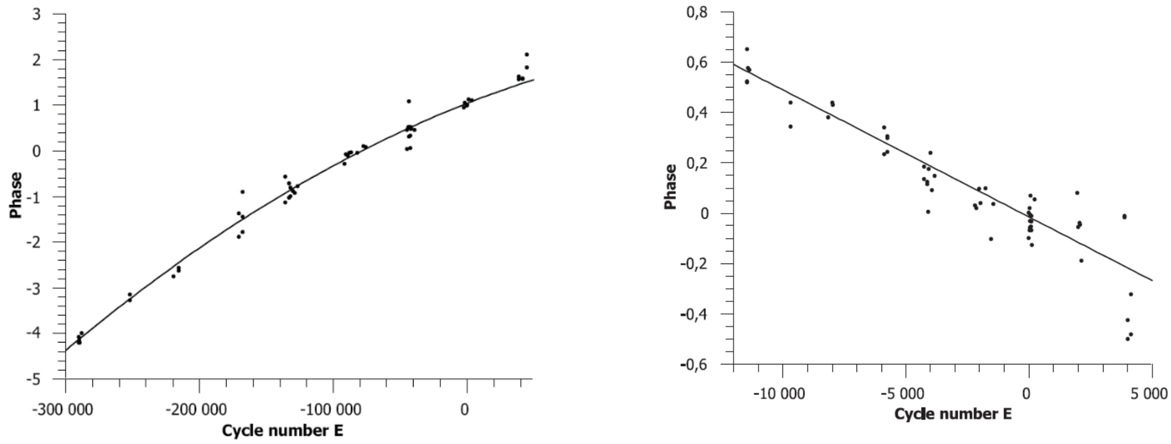

Figure 1: Dependence of phases of spin maxima on the cycle number (left) and dependence of phases of orbital minima on the cycle number during the second iteration of O-C analysis (right) with weighted polynomial approximation of statistically optimal order.

Later on, Breus et al. (2015) corrected the value of the orbital period of V2306 Cyg, but they were not successful in studying spin period variability due to lack of data. We derived the value of the orbital period of $0.^{d}18214681 \pm 0.00000037$ and found the statistically significant second-order polynomial fit for the O-C compiled

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using all available spin maxima timings (see Breus et al., 2019). For the epoch of 2017, the white dwarf rotation period was 1466.6795±0.0003 seconds. The characteristic spin-up time is (53 ± 5) * 10^4 years and its order is typical of intermediate polars.

Two-period variability of MU Camelopardalis

We analyzed data obtained from the Astronomical Observatory on Kolonica Saddle and from M.R. Stefanik Observatory in Hlohovec, Slovakia.

The O-C diagram of spin pulse maxima based on the ephemeris

$$BJD_{max} = 2452682.4181 + 0.01374116815 * E$$

are presented at the Fig. 2. Residuals from the quadratic fit

$$BJD_{max} = 2452682.4181 + 0.0137412342412802 * E - 1.52 * 10^{-12} * E^2$$

are presented at the Fig. 3.

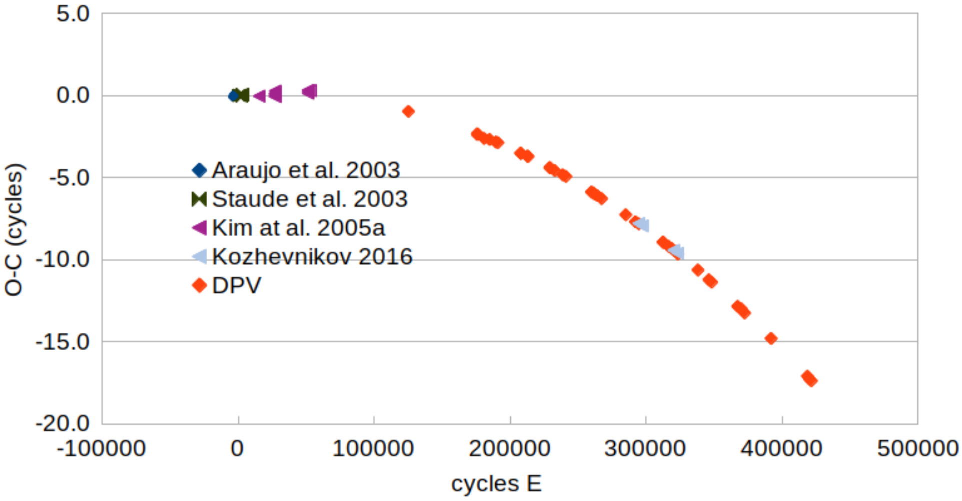

Figure 2: O-C diagram of spin pulse maxima of MU Cam. Our observations are labelled as DPV.

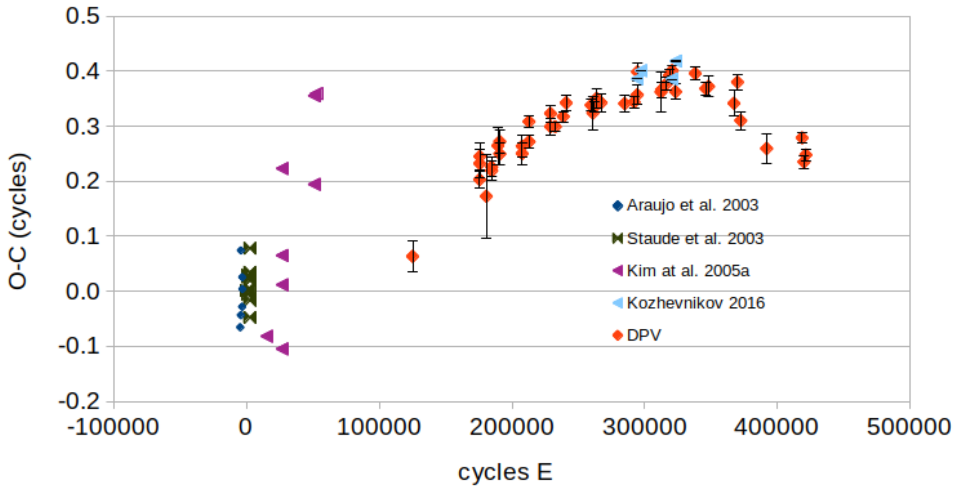

Figure 3: Residuals from the quadratic fit.

As a possible source of the unexpected scatter on this plot we have investigated the dependency of spin maxima timings on orbital phase following the analysis by Kim et al., 2005. Mean spin maxima were determined for 10 phase intervals: 0.0 - 0.1; 0.1 - 0.2 ... Only long time series were used to achieve higher precision (see Fig. 4). The amplitude and shape are changing, but there is no unambiguous dependency on orbital phase.

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Periodogram analysis reveals two correlations:

- High amplitude of O-C variations of spin maxima - strong sideband signal. Low amplitude – low or no sideband signal.
- Orbital sideband appears mainly in low states of the long-term light curve.

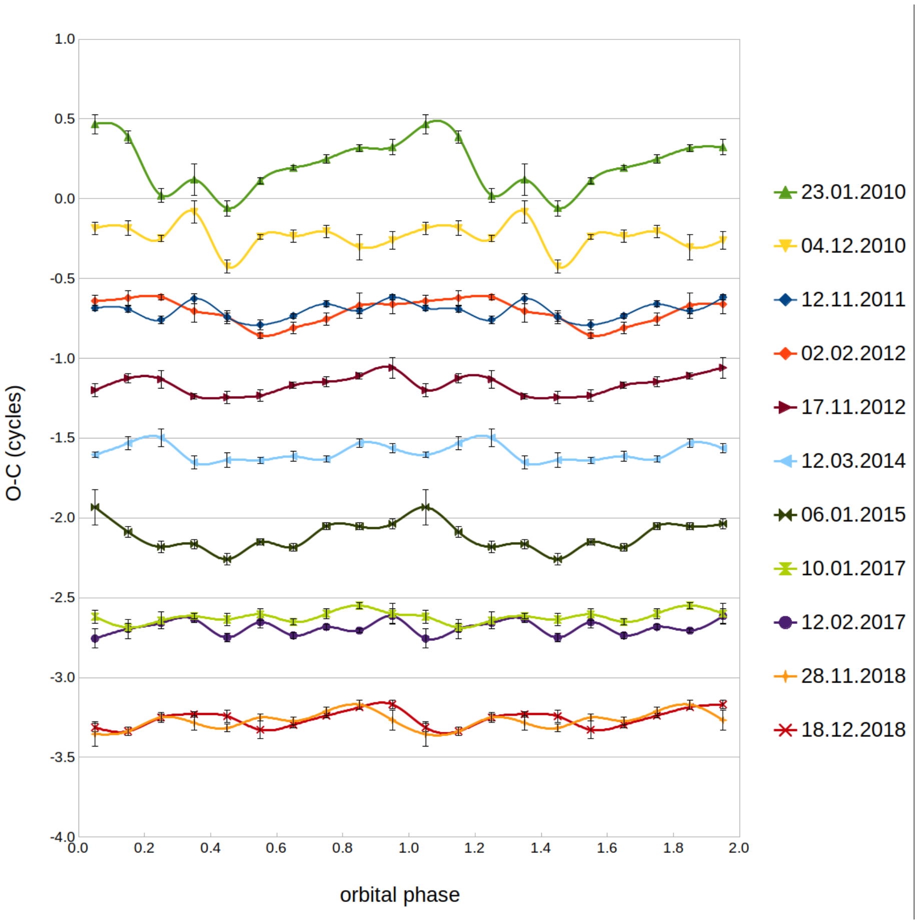

Figure 4: Dependence of O-C on orbital phase. For clarity the plots are arbitrary shifted by 0.5 cycle between seasons.

We performed photometric observations of MU Cam, analyzed published and own data and obtained important results. Spin maxima phase changes are caused by the interaction with the orbital sidebands frequencies as already proposed by Warner (1986). The presence of orbital sidebands is more prominent in low states but not only. The origin of orbital sidebands can be direct accretion from the stream and / or reprocessing of X-rays at some part of the system which rotates with the orbital period. The low states in intermediate polars are connected with lower mass transfer in the system. In that situation the disc-fed accretion should be lower.

On the spin and superhump variability of RX J2133.7+5107

RX J2133.7+5107 was discovered in 1998. The orbital and spin periods were determined and confirmed from spectroscopy and photometry. De Miguel et al. (2017) observed this object in 2010-2016. They interpreted a modulation with 6.72-h period not as an orbital but as negative superhump variability. They proposed a parabolic fit to the (O-C) diagram of the spin maxima timings obtained during 7 years, which corresponds to characteristic time of spin-up $0.17*10^6$ years. They concluded that it is the shortest value along all known intermediate polars with spin-up of the white dwarf.

Using our own data gathered during 12 years (2007-2019), we determined the value of the spin-up time-scale $1.5*10^5$ years. The observed rate of spin-up is even faster then reported by previous authors (see Fig. 5). We discovered a long-term variability of the spin period with a period of about 7 years. The reason of these changes is a subject for discussions - either the spin rotation rate is changing near its equilibrium period, or there is a third body in this system. We confirm the presence of negative superhumps in this system. The superhump period looks to be stable from year to year, but further research is required.

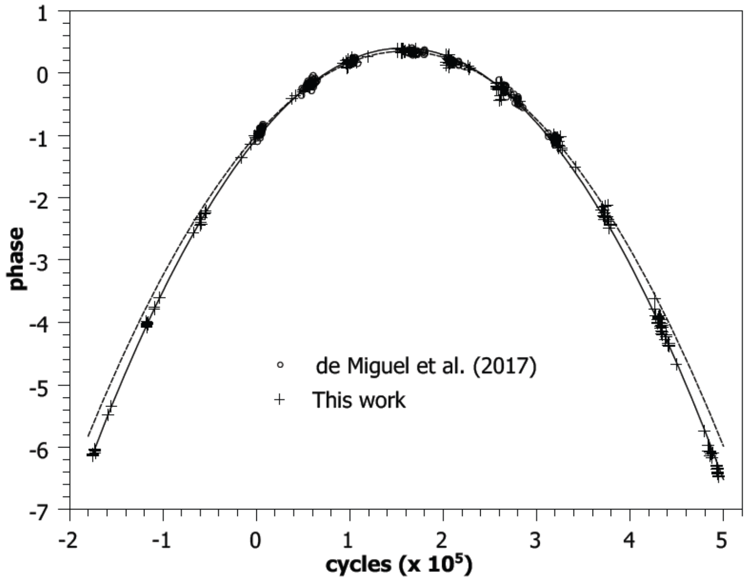

Figure 5: Dependence of phases of spin maxima on the cycle number. Timings published by de Miguel (2017) are marked with circles; our data is marked as crosses. We present two fits. Dashed line corresponds to fit published by de Miguel (2017), solid line – to our fit calculated for all data.

Discussion and Conclusions

Period variations are often observed in intermediate polars and are typically detectable at a time scale of decades. They may be caused by different physical processes and should be monitored (Andronov et al., 2017). From theoretical expectations, the spin periods of the white dwarf should be equal to some equilibrium value, which is equal to period of "Kepler" rotation of the inner accretion disk at a distance of the magnetosphere radius. O-C analysis on the time scale of decades usually allows us to obtain the value of characteristic time of period variations with high precision. We obtained this value for V2306 Cygni and RX J2133.7+5107. From the CCD photometry of MU Cam, we found that spin maxima phase changes are caused by the interaction with the orbital sidebands frequencies. The importance of long time series observations covering at least one orbital period was demonstrated.

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References

Andronov I.L. et al., 2011, JKAS, 44, 89, 2011JKAS...44...89K

Andronov I.L. et al., 2017, ASPC, 511, 43, 2017ASPC..511...43A

Andronov I. L., Mishevskiy N., Breus V. 2017, RNAAS, 1, 1, 20, 2017RNAAS...1...20A

Andronov I. L., Baklanov A. V., 2004, Astron. School Rep., 5, 264, 2004AstSR...5..264A

Andronov I. L., Breus V. V., 2013, Astrophysics, 56, 4, 518-530, 2013Ap.....56..518A

Breus V. V., 2003, OAP, 16, 24-26, 2003OAP....16...24B

Breus V. V., 2007, OAP, 20(1), 32-35, 2007OAP....20...32B

Breus V., Petrik K., Zola S., 2019, MNRAS, 488, 4526, 2019MNRAS.488.4526B

Breus V. V., Andronov I. L., Dubovsky P., Petrik K., Zola S., 2019, OEJV, 197, 8, 2019OEJV..197....8B

Breus V. V. Petrik K., Baransky A., Hegedus, T., 2014, YSC, 18, 2014ysc..conf...18B

Breus V., Andronov I. L., Yoon J., Dubovsky P. 2017, The Astronomer's Telegram, 10477, 2017ATel10477....1B

Breus V. V., Andronov I. L., Dubovsky P., Kim Y. et al., 2014, Proceedings of RAGtime 14-16, 19, 2014bhns.work...19B

Breus V. V., Andronov I. L., Dubovsky P., Kolesnikov S. V. et al., 2013, JPhSt, 17, 3901, 2013..17.3901B

Breus, V. V., Andronov I. L., Hegedus T., Dubovsky P. A., Kudzej I., 2012, AASP, 2, 9, 2012AASP....2....9B

Breus V., Petrik K., Zola S., Baransky A., Hegedus T., 2015, AASP, 5, 17, 2015AASP....5...17B

Hric L., Breus V., Katysheva N. A., Shugarov S.Yu., Dubovský P., 2014, AN, 335, 362, 2014AN....335..362H

Kim Y., Andronov I. L., Jeon Y., 2004, JASS, 21, 3, 191-200, 2004JASS...21..191K

Kim Y., Andronov I. L. et al., 2005, JASS, 22, 197, 2005JASS...22..197K

Kudzej I. et al., 2019, Astronomische Nachrichten, 340, 1-3, 68-70, 2019AN....340...68K

de Miguel E. et al., 2017, MNRAS, 467, 1, 428-436, 2017MNRAS.467..428D

Motl D., 2011, C-Munipack project http://c-munipack.sourceforge.net/

Norton A. J., Quaintrell H., Katajainen S., Lehto H. J., Mukai K., Negueruela I., 2002, A&A, 384, 195, 2002A&A...384..195N

Patterson J., 1994, PASP, 106, 209, 1994PASP..106..209P

Petrik K, Breus V., Andronov I.L. et al., 2015, ASPC, 496, 252, 2015ASPC..496..252P

Zharikov S. V., Tovmassian G. H., Echevarria J., 2002, A&A, 390, L23, 2002A&A...390L..23Z

Warner, B., 1986, MNRAS, 219, 347, 1986MNRAS.219..347W

Warner B., 2003, ”Cataclysmic Variable Stars”, Cambridge University Press, 592pp., 2003cvs..book.....W

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Photometric and spectroscopic observation of symbiotic variables at private observatory Liptovská Štiavnica

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Abstract: Symbiotic systems are wide binaries with orbital periods of hundreds to thousands of days and their stages of activity may last from a few days to decades. A new multicolour (UBVRcIc) photometric observations and low-resolution spectra of symbiotic stars Z And, AG Dra, BF Cyg, V1016 Cyg, CI Cyg, CH Cyg, AG Peg and AX Per is presented. The photometry and spectroscopy data were obtained at private observatory Liptovská Štiavnica.

Introduction

Symbiotic stars are strongly interacting systems, in which physical mechanisms related to the mass transfer and accretion cause observable activity by manifesting increases of brightness (about 2–5mag) and significant changes in their spectra. These binaries consist of a cool giant of spectral type K-M and a hot compact star, mostly a white dwarf. The mass transfer most likely takes place via the stellar wind of the cool giant, which is also the source of the dense circumbinary envelope of these systems.

Observations and data reduction

Photometric data of symbiotic systems were obtained at private observatory Liptovská Štiavnica (LSO) from 2016 October to 2020 January by the metod of classical CCD photometry. A CCD camera MII G2-1600 and a Johnson-Cousins set of filters were mounted at the Newtonian focus of a 0.35-m telescope. The chip of the camera is KAF 1600 (16 bit), with dimensions of 13.8×9.2mm or 1536×1024 pixels. The pixel size is 9×9 μm and the scale 1”.16/pixel. The readout noise was 12 ADU/pixel and the gain 1.5 e-/ADU. All frames were dark subtracted and flat fielded. Photometry was made with MuniWin routines. The differential magnitudes of the variables were calculated using transform coefficients into the standard Johnson-Cousins photometric magnitudes.

Low-resolution spectra were obtained at 0.35-m telescope with Czerny – Turner spectrograph (R = 1000) from 2019 September to 2019 November. Spectral range of spectrograph is from 3200 to 8500 Å. Dispersion element is optical reflection grating 300 l/mm, 500 nm blaze, dispersion 2.03 Å/px. Width of slit is 18 μm, 3 mm long. Imaging camera is ATIK 414EX with Sony ICX825 CCD sensor. For spectrum processing was used Demetra and PlotSpectra software.

Table 1: Data for the measured symbiotic stars

Symbiotic stars							
Name	V mag	α(2000)	δ(2000)	Orbital photometric ephemerides	Eclipse	Pulsation ephemerides for Miras	Type
Z And	10.0	23 33 39.5	+48 49 05.4	Min=2442666+758.8*E	no		ZAnd
AG Dra	9.7	16 01 40.5	+66 48 09.5	Max=2443886+554*E	no		ZAnd
BF Cyg	9.7	19 23 53.4	+29 40 25.1	Min=2415058+756.8*E	yes		ZAnd
V1016Cyg	11.6	19 57 04.9	+39 49 33.9			Min=2444852+478*E	SyN
CI Cyg	10.8	19 50 11.8	+35 41 03.2	Min=2442687.1+855.6*E	yes		ZAnd
CH Cyg	7.1	19 24 33.0	+50 14 29.1	Min=2446275+5700*E	yes		
AG Peg	8.5	21 51 01.9	+12 37 29.4	Max=2442710+816.5*E	no		SyN
AX Per	11.5	01 36 22.7	+54 15 02.5	Min=2436667+680.8*E	yes		ZAnd

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Light curves and specra of the measured objects

Table 2: Magnitudes of the comparison stars used for each target

Name	V	B-V	U-B	V-Rc	Rc-Ic	Ref
			Comparison star in the field of Z And			
„γ“ = SAO53133	9.229	1.320	1.229	0.744	0.681	1
			Comparison star in the field of AG Dra			
„a“ = UCAC4-784-024942	10.459	0.559	0.015	0.333	0.349	1,2
			Comparison star in the field of BF Cyg			
„b“ = UCAC4-599-077441	12.417	0.291	0.182	0.155	0.173	1
			Comparison star in the field of V1016 Cyg			
„a“ = UCAC4-650-080998	12.314	0.552	0.085	0.334	0.315	1
			Comparison star in the field of CI Cyg			
„b“ = UCAC4-629-081135	11.722	0.274	0.198	0.159	0.173	1
			Comparison star in the field of CH Cyg			
„b“ = UCAC4-701-067161	9.475	0.546	0.079	0.349	0.293	1
„e“ = UCAC4-701-067161	10.852	1.408	1.693	0.790	0.637	1
			Comparison star in the field of AG Peg			
„b“ = UCAC4-514-136407	10.672	0.832	0.528	0.508	0.430	1
			Comparison star in the field of AX Per			
„β“ = UCAC4-722-014021	11.156	1.167	0.993	0.608	0.531	1

Refs: 1. Henden – Munari III (2006), 2. this paper (Ic magnitude)

Table 3: Equivalent widths of measured spectral lines He II (4686 Å) and Hbeta (4861 Å) and temperatures of hot component calculated by relationship (Ijima 1981): T_{hot} (in 10^4 K) = $14.16 \times \sqrt{EW4686 \div EWH\beta} + 5.13$

Name	EW (He II 4686) Å	EW (Hbeta 4861) Å	He II/Hbeta ratio	Teff 10^4 K
Z And	29.102	50.015	0.582	15.9
AG Dra	17.274	23.611	0.732	17.2
BF Cyg	-	17.464	-	-
V1016 Cyg	179.554	452.379	0.379	14.1
CI Cyg	28.404	46.307	0.613	16.2
CH Cyg	-	22.576	-	-
AG Peg	31.422	39.107	0.803	17.8
AX Per	13.946	66.773	0.209	11.6

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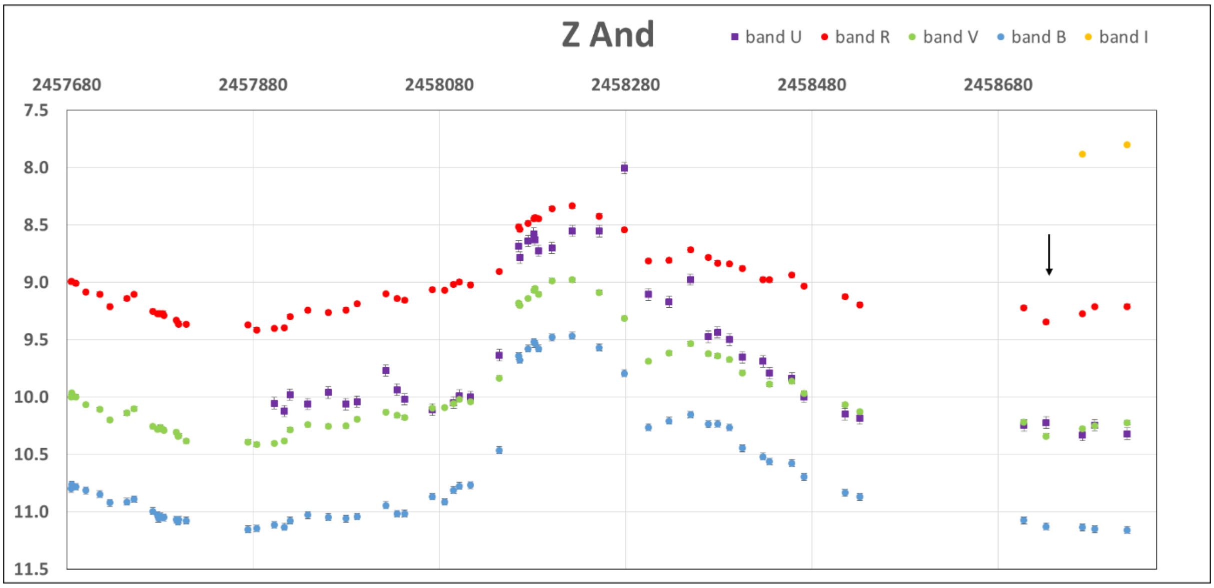

Figure 1: The light curve of Z And obtained from JD 2457684 to 2458818. A black arrow indicates time of the presented spectrum.

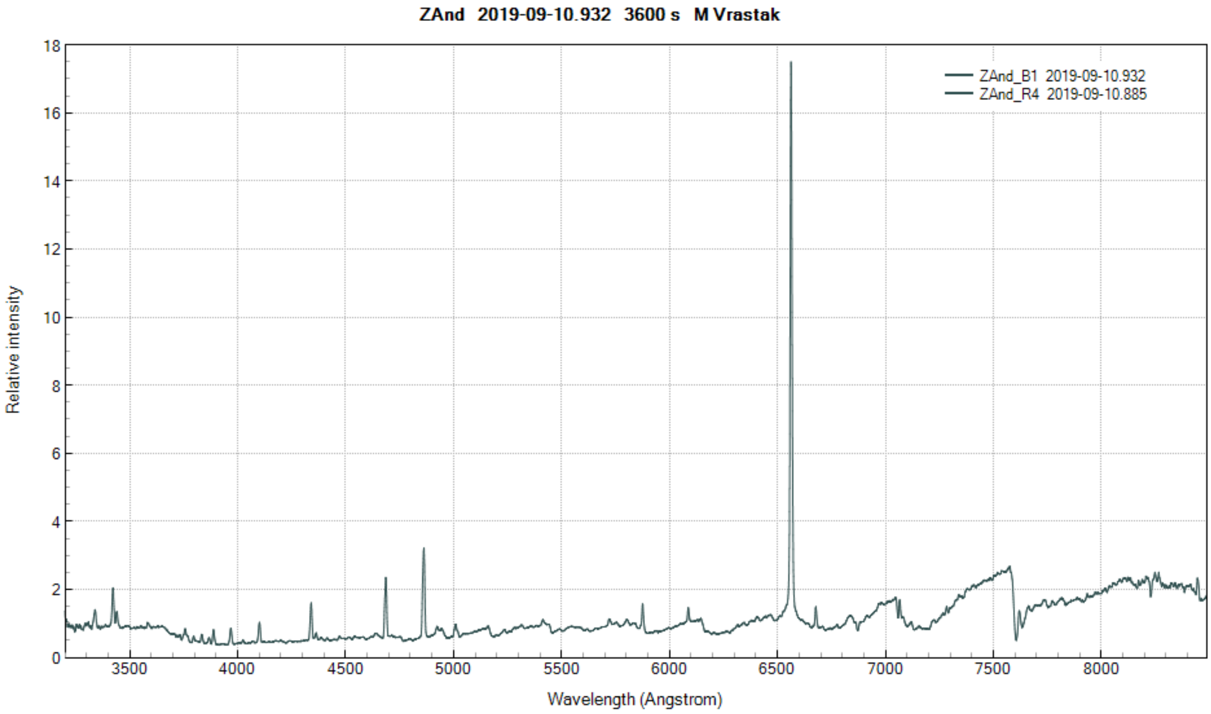

Figure 2: Spectrum of Z And obtained at 2019-09-10.932, JD 2458737.432

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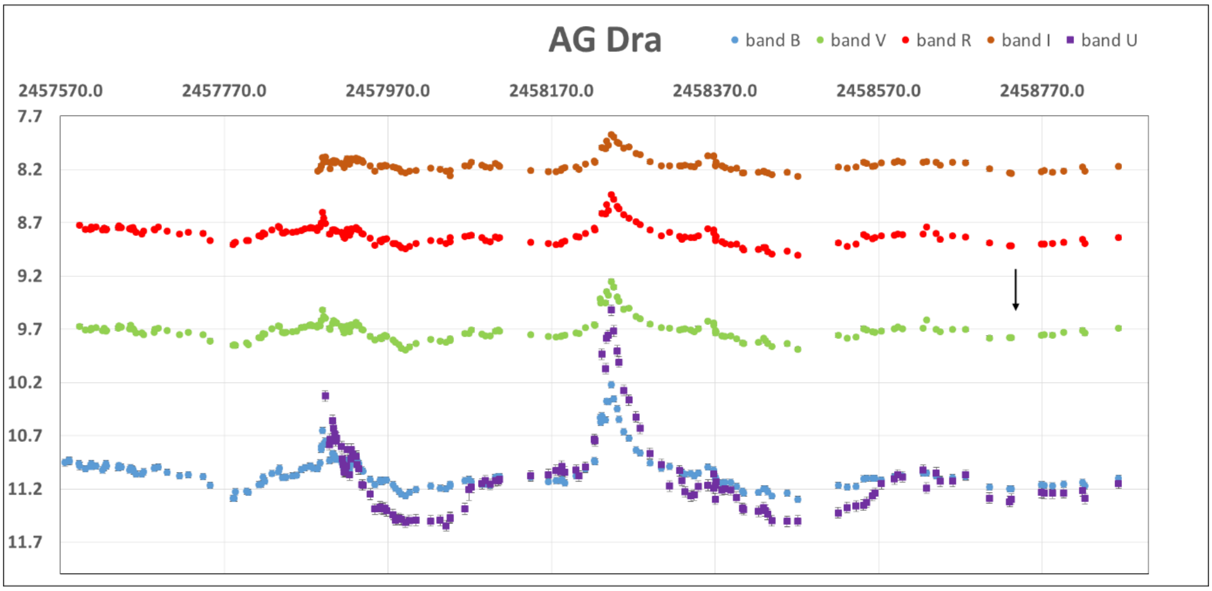

Figure 3: The light curve of AG Dra obtained from JD 2457575 to 2458863. A black arrow indicates time of the presented spectrum.

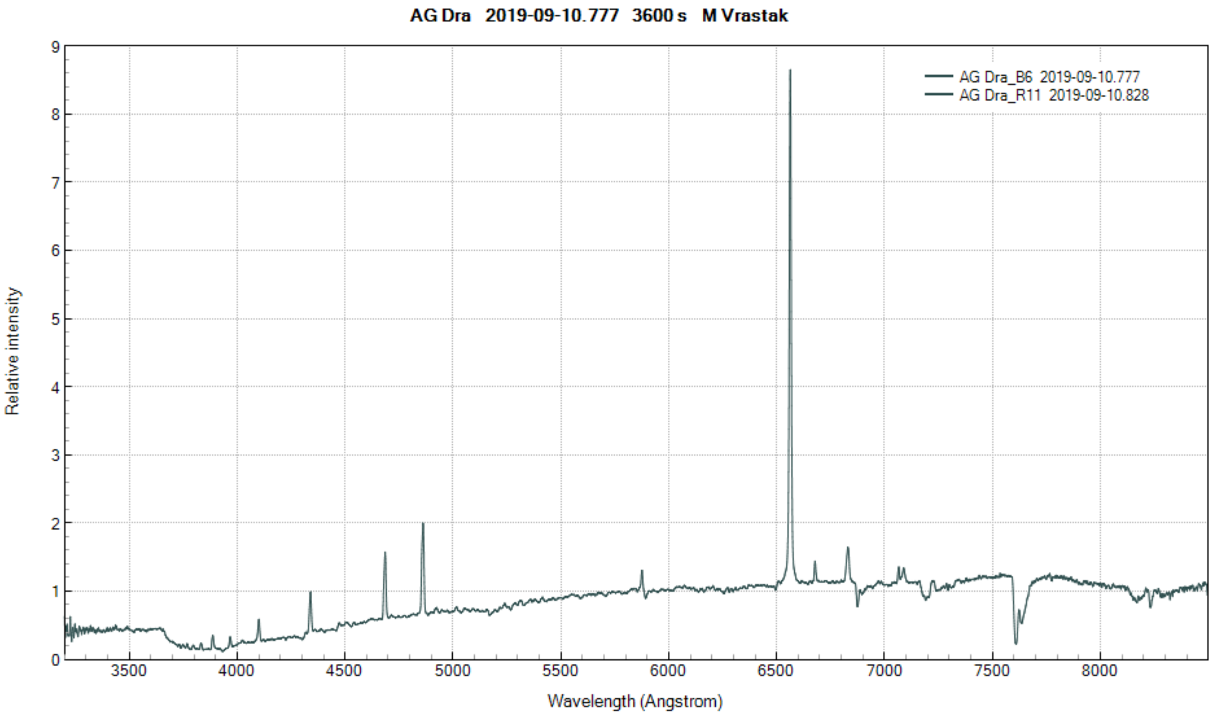

Figure 4: Spectrum of AG Dra obtained at 2019-09-10.777, JD 2458737.277

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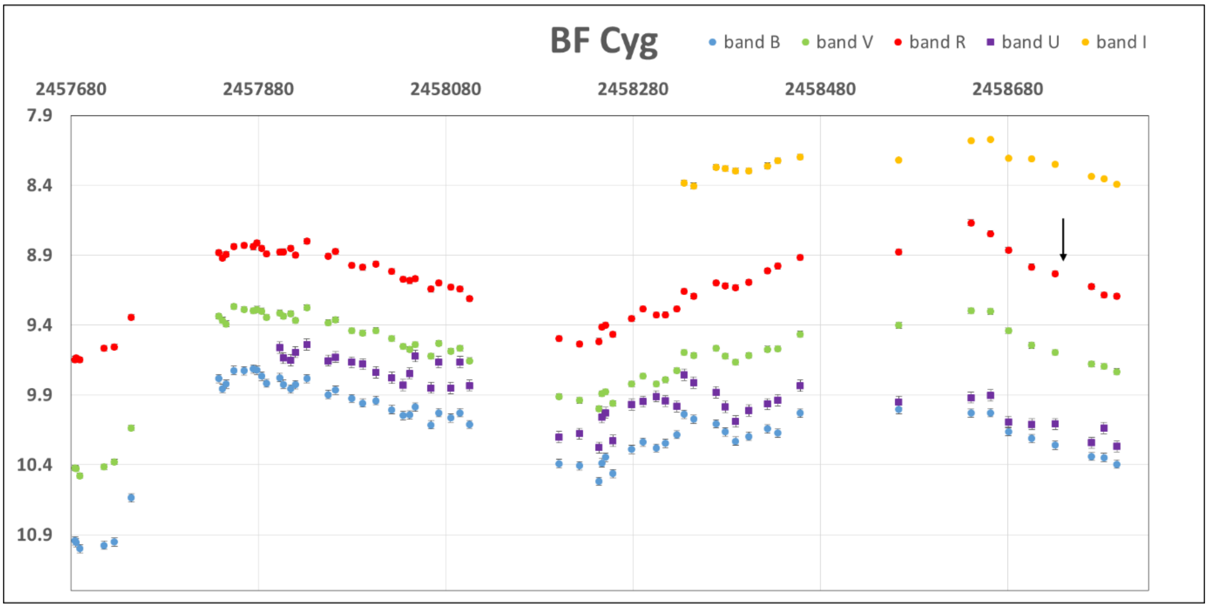

Figure 5: The light curve of BF Cyg obtained from JD 2457684 to 2458796. A black arrow indicates time of the presented spectrum.

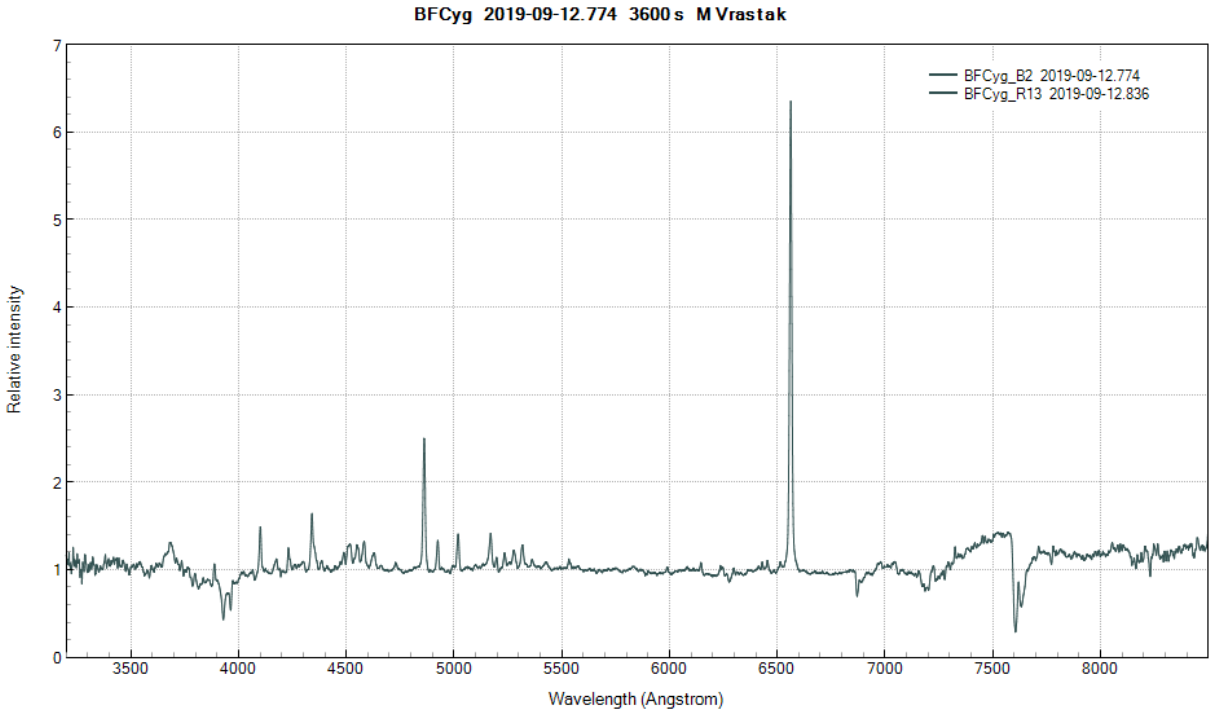

Figure 6: Spectrum of BF Cyg obtained at 2019-09-12.774, JD 2458739.274

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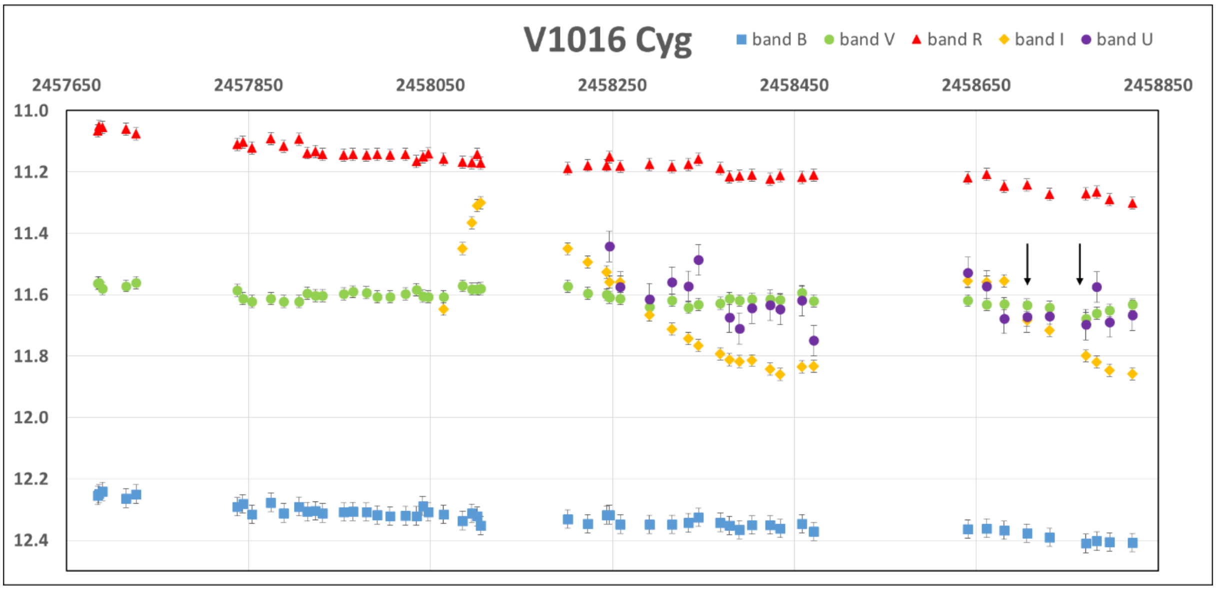

Figure 7: The light curve of V1016 Cyg obtained from JD 2457684 to 2458821. A black arrows indicates times of the presented spectrum.

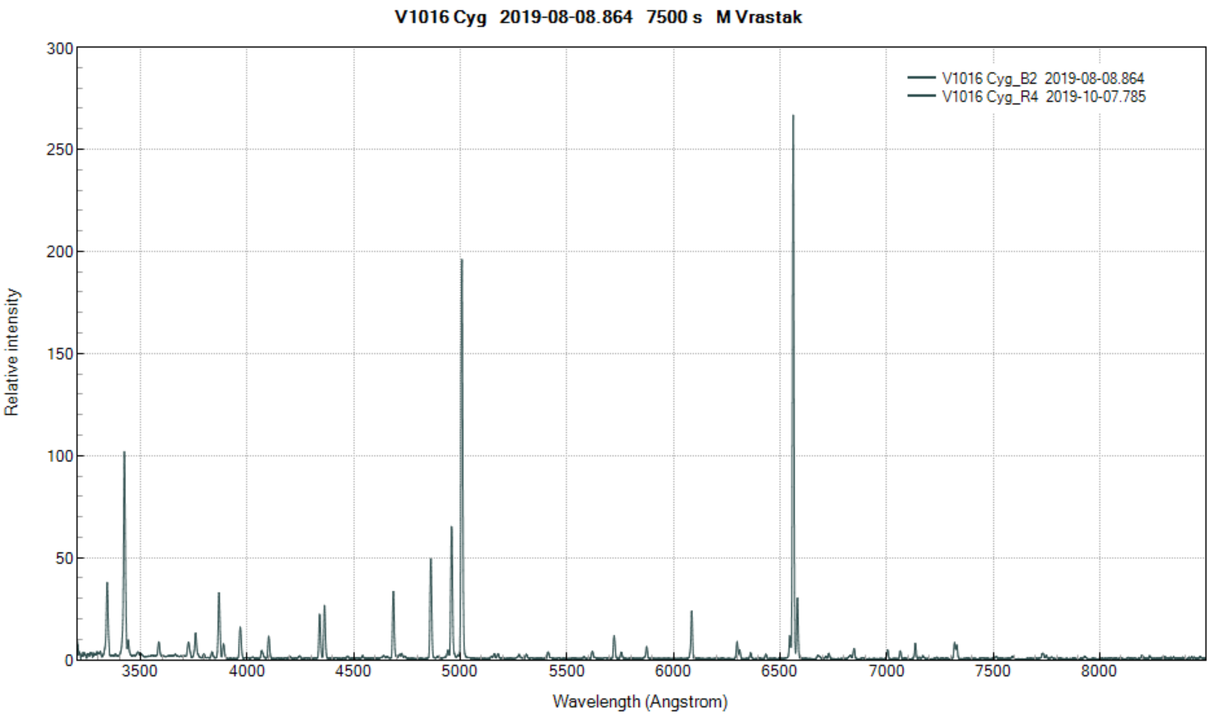

Figure 8: Spectrum of 1016 Cyg obtained at 2019-08-08.864, JD 2458704.364 (3200 – 5800 A) and 2019-10- 07.785, JD 2458764.285 (5800 – 8500 Å), respectively

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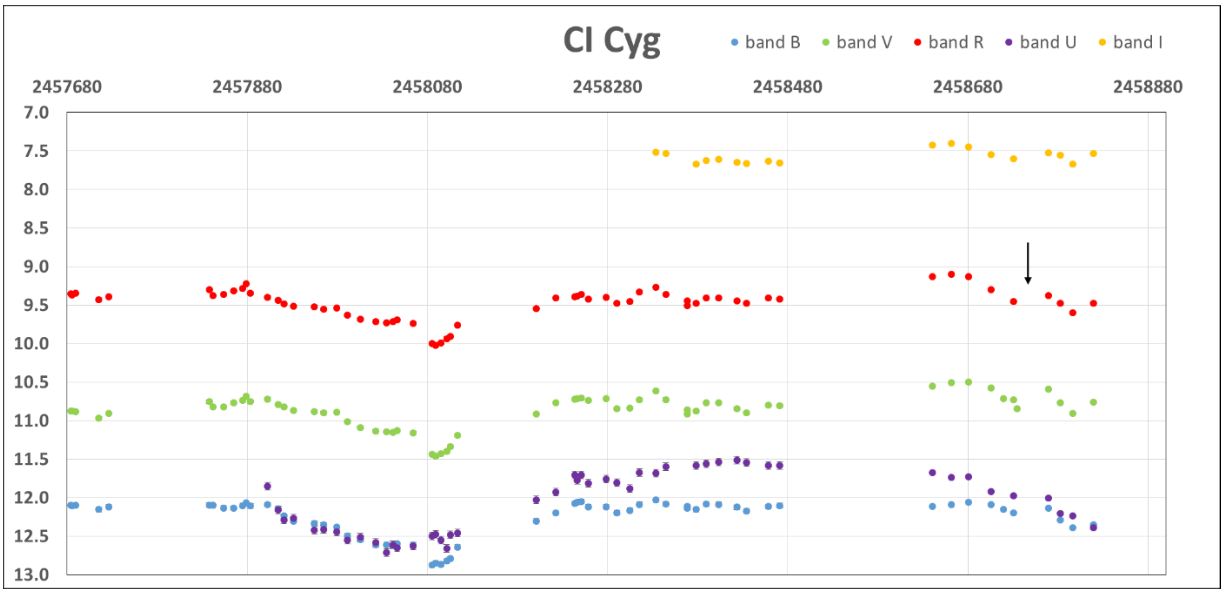

Figure 9: The light curve of CI Cyg obtained from JD 2457684 to 2458819. A black arrow indicates time of the presented spectrum.

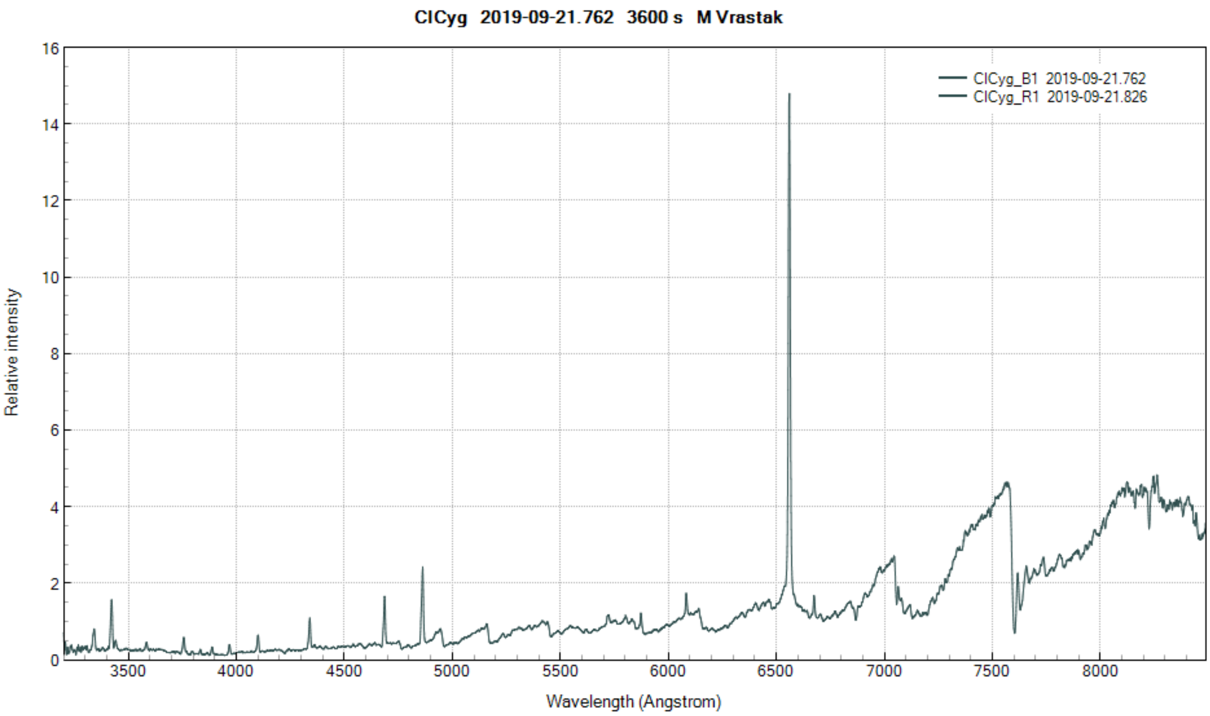

Figure 10: Spectrum of CI Cyg obtained at 2019-09-21.762, JD 2458748.261

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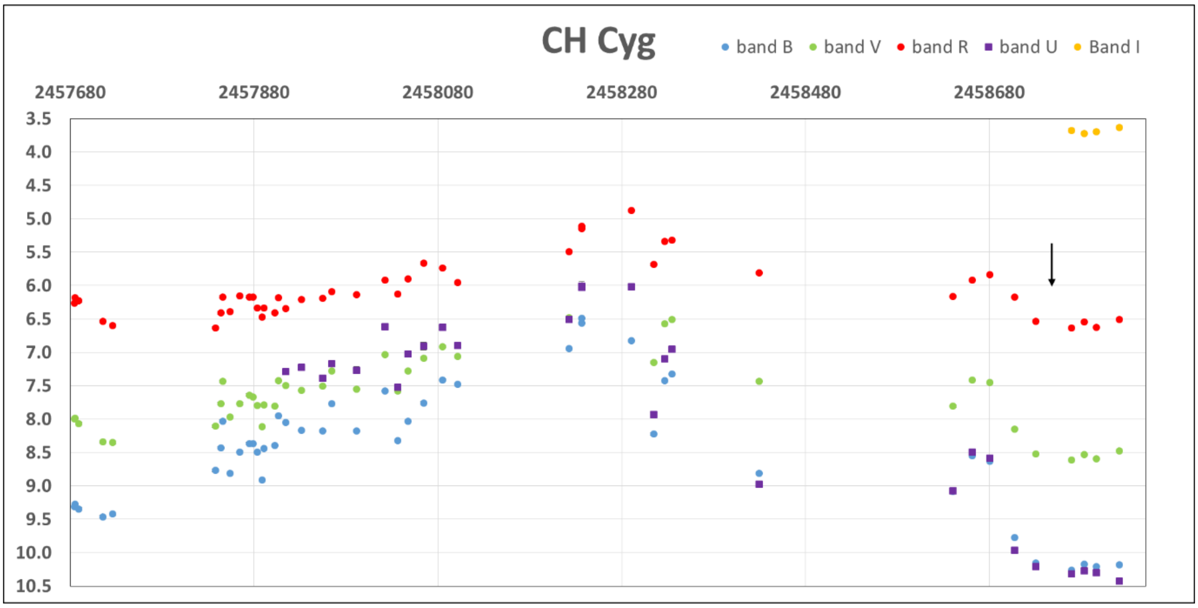

Figure 11: The light curve of CH Cyg obtained from JD 2457684 to 2458821. A black arrow indicates time of the presented spectrum.

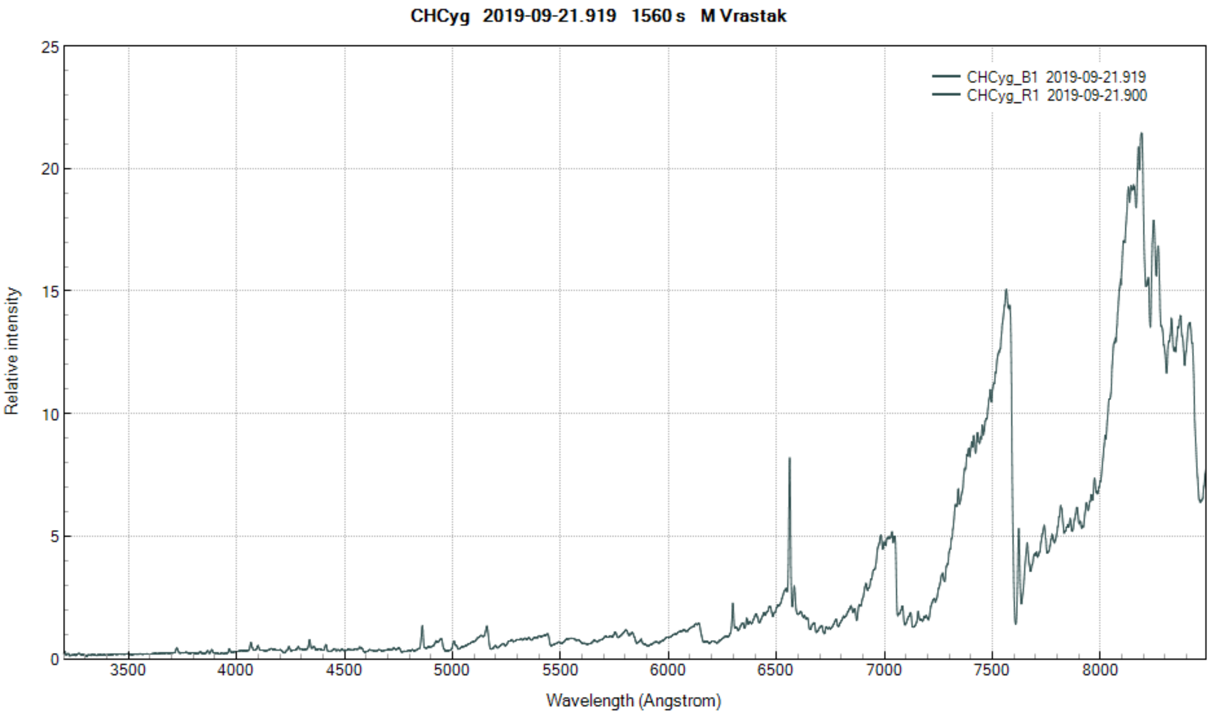

Figure 12: Spectrum of CH Cyg obtained at 2019-09-21.919, JD 2458748.418

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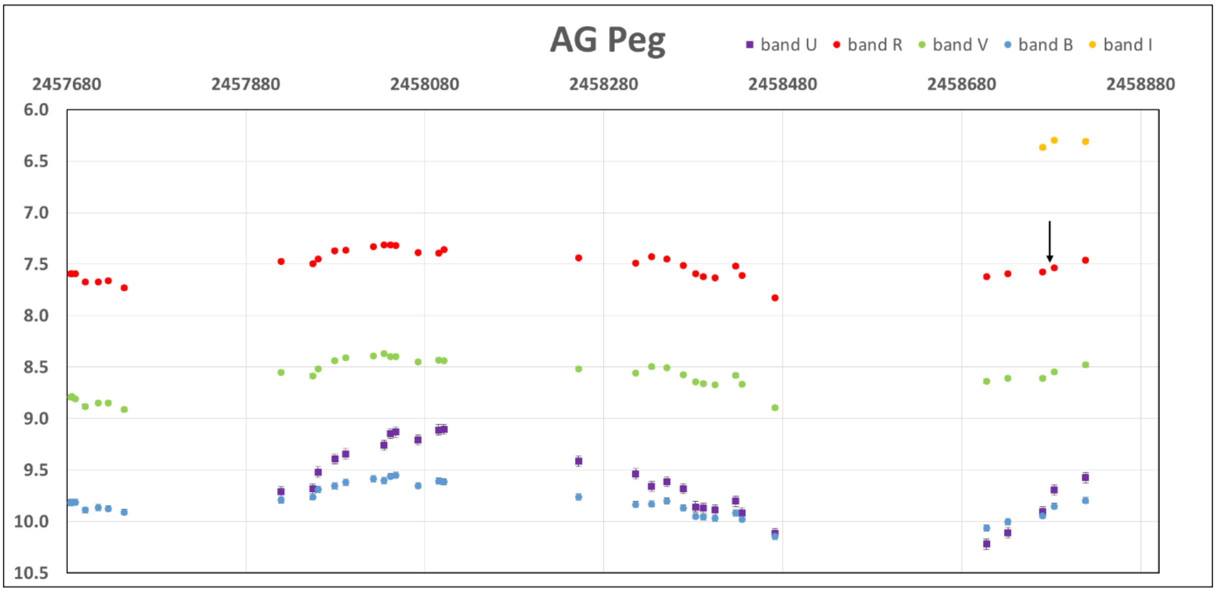

Figure 13: The light curve of AG Peg obtained from JD 2457684 to 2458818. A black arrow indicates time of the presented spectrum.

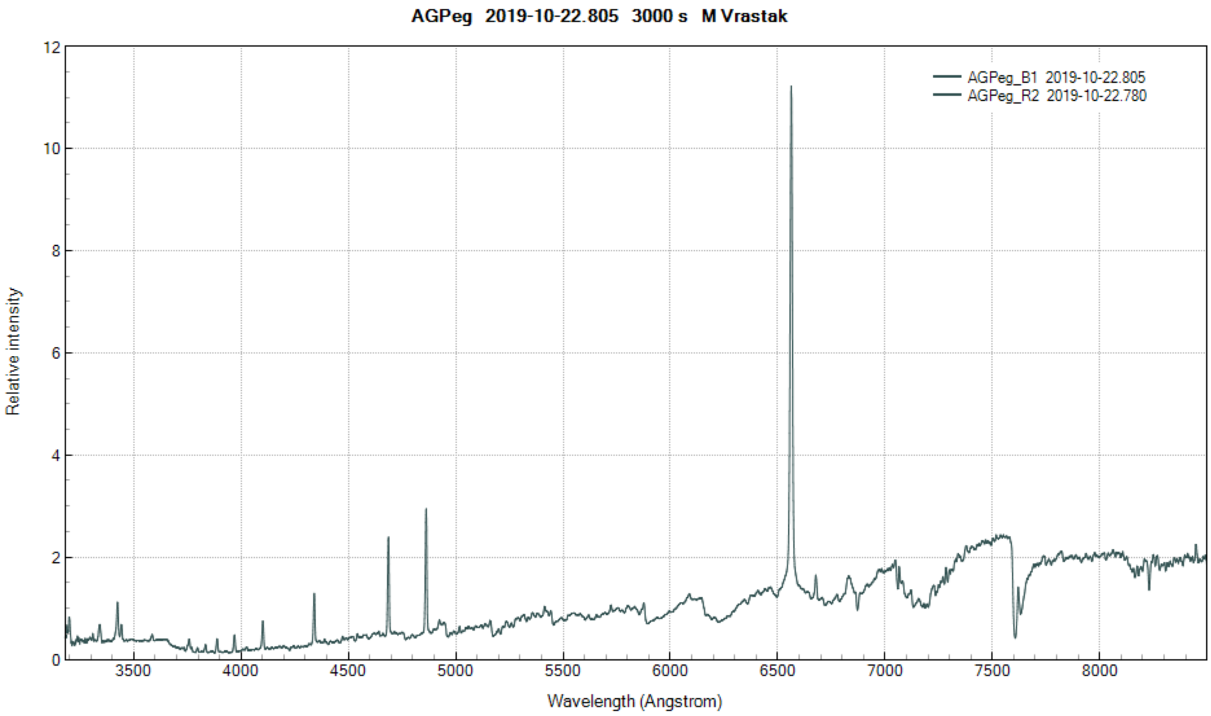

Figure 14: Spectrum of AG Peg obtained at 2019-10-22.805, JD 2458779.304

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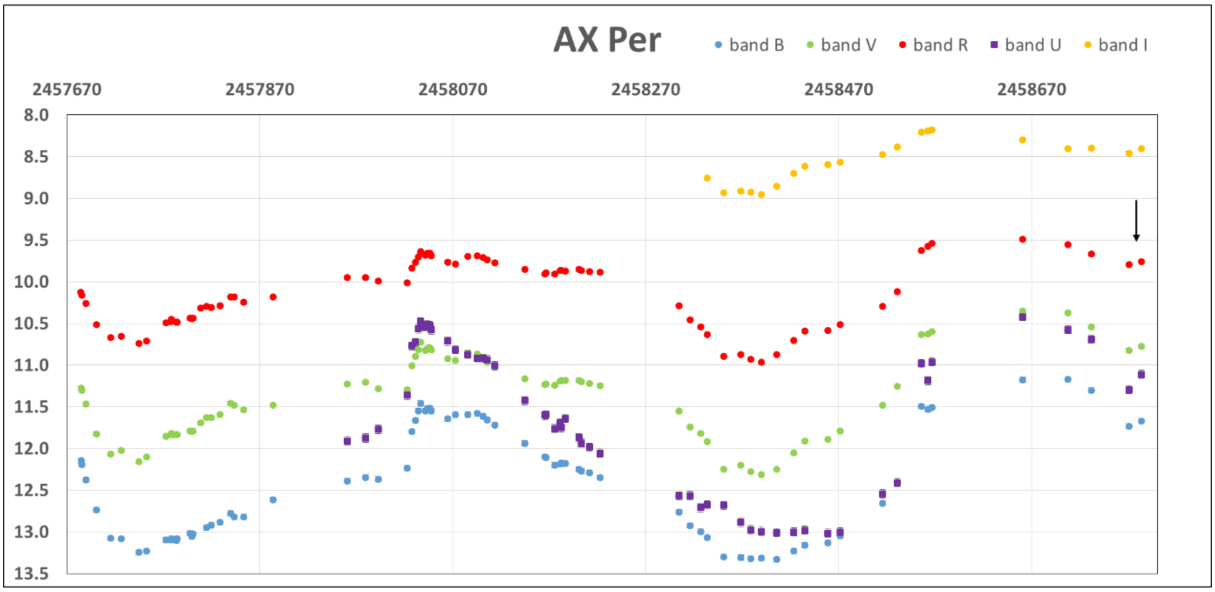

Figure 15: The light curve of AX Per obtained from JD 2457684 to 2458863. A black arrow indicates time of the presented spectrum.

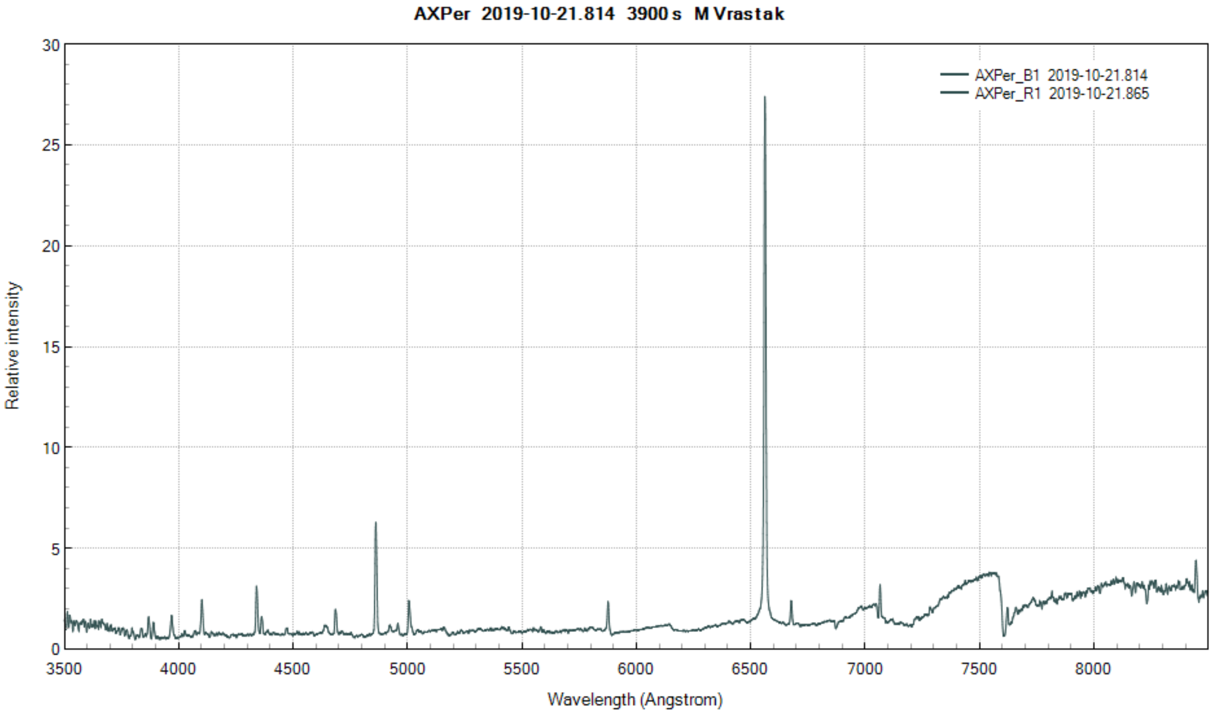

Figure 16: Spectrum of AX Per obtained at 2019-10-21.814, JD 2458778.314

References

Merc J, Gális R, Leedjärv L., Recent outburst activity of the symbiotic binary AG Draconis, 2018, PoS, 2017gacv.workE..60M

Sekeráš M, Skopal A, Shugarov S, Shagatova N, Kundra E, Komžík R, Vrašťák M, Peneva S P, Semkov E, Stubbings R, Photometry of Symbiotic Stars – XIV, CAOSP 49, 19-66, 2019, 2019CoSka..49...19S

A.Henden, U.Munari, UBV(RI)C photometric comparison sequences for symbiotic stars I, II, III, 2006A&A...458..339H,

K.Belczynski et al., A catalogue of symbiotic stars, 2008

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Outburst activity of flare stars 2014 – 2019

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Abstract:

In 2014, we began monitoring selected eruptive stars in cooperation with the Variable Stars and Exoplanet Section. During this period, some of the known variable stars or new eruptive stars were discovered. The activity level of individual objects is different and is expressed by the parameter of frequency of eruptions per hour. During photometry we revealed various courses of eruption light curves, which are probably related to the mechanism of eruption formation.

Introduction:

Eruptive variable stars of the UV Cet type are an important group of objects through which we can study rapid changes in brightness caused probably by magnetic reconstruction. They are usually cold low mass stars on the main sequence with emission hydrogen lines in the spectrum. There is speculation about the similarity of the eruption mechanism of these stars with solar flares. The difference is in the amount of energy released, which can be two to three orders of magnitude greater than that of solar flares. Since these objects are poorly luminous, it is difficult to obtain a light curve with sufficient time resolution. In the early days of astronomical photography, the brightening of a star during an eruption on photographic plates was usually randomly discovered.

Thus, the brightness of the prototype of this group of variable stars UV Cet was recorded on the boards of the Hardvard Observatory on 9.11. 1900 and several other similar stars until 1952 (Plum Z., 1954). Until then, it was not possible to obtain a light curve during the entire eruption. Thus, it was not possible to determine exactly the amplitude of the brightness and the duration of the eruptions. With the advent of photoelectric photometers and, in recent years, CCD cameras, the situation has improved significantly.

Observations:

In the following chapter we present an overview of the eruptive activity of long-term monitored objects of known variable stars and several newly discovered eruptive stars. The eruption statistics are processed from data collected at the observatory in Valašské Meziříčí between 2013 and 2019.

GJ 3236

It is a eclipsing binary consisting of two red dwarfs. The circulation period of 0.77126 was first published by Irvin (Irvin J., 2009). The first documented eruption was observed on 20.3. 2014 (Šmelcer L., 2015) and a more detailed analysis was published in 2017 (Šmelcer L., 2017). This eclipsing system was within 12.3. 2014 to 25.11. 2019 observed during 222 nights, ie 1467 hours. A total of 102 eruptions were recorded, representing a frequency of 0.06954 eruptions per hour (or 1 eruption per 14.38 hours).

BX Tri

The discovery of variability as an eclipsing binary from the Northern Sky Variability Survey (NSVS) project (Wozniak P., 2004) states the orbital time of 0.192637 days. in the range of 16 December 2013 to 30 November 2019 during 41 nights, ie 202 hours, a total of 2 eruptions were recorded, representing a frequency of 0.00987 eruptions per hour (or 1 eruption per 101.3 hours).

NSVS 01031772 Cam

The discovery of this eclipsing binary is published in López-Morales (2006). The period of circulation is 0.3681414 days. The first eruption was observed on 29.3. 2014 (Šmelcer L. 2016). This eclipsing system was in the 8.7 range. 2013 to 13.10. 2019 observed during 120 nights, ie 574.3 hours. A total of 19 eruptions were recorded, representing a frequency of 0.0331 eruptions per hour (or 1 eruption per 30.25 hours).

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V0667 Ser (TYC 5112-252-1 Ser)

The discovery of this eclipsing binary is published in Kiraga (2013). The period of circulation is 0.976936 days. The eruption activity was first recorded by Ladislav Červinka from Mladá Boleslav (Šmelcer L., 2018). This eclipsing system was within 24.6. 2017 to 18.7. 2019 observed during 26 nights, ie 100.8 hours. A total of 1 eruption was recorded, representing a frequency of 0.0099 eruptions per hour (or 1 eruption per 101.01 hours).

References

Dimitrov D.P., Kjurkchieva D.P., 2010, MNRAS, 2010MNRAS.406.2559D

Irvin J., Charbonneau D., Berta Z.K., 2009, ApJ, 701, 1436, 2009ApJ...701.1436I

Kiraga M., Stepien K., 2013, Acta Astronomica, vol. 63 no1, p. 53-66

López-Morales M., Orosz A., Shaw J.S., 2006, arXiv:astro-ph/0610225v1, 2006astro.ph.10225L

Švestka Z., 1954, BAIC, 1954BAICz…5….1S

Šmelcer L., 2015, OEJV, 2015OEJV..169…14S

Šmelcer L., Wolf M., Kučáková H., 2017, MNRAS, 2017MNRAS.466.2542S

Šmelcer L., Bílek F., Pečiva T., 2016, OEJV, 2016OEJV..175….1S

Šmelcer L., Červinka L., Mašek M., 2018, OEJV, 2018OEJV..192….1S

Wozniak P.R., Vestrand C.W., Akerlof R., et a., 2004, AJ, 127, 2436, 2004AJ….127.2436W