THE IR-PHOTOMETRIC BEHAVIOUR OF THE YOUNG STARS VX CAS AND V517 CYG

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Introduction

The main characteristic of light curves of UX Ori stars (UXors) is irregular Algol-like brightness dips ($\Delta m \sim 3$-4m). The light variability seems to be due to extinction fluctuations in heterogeneous gas-dust disks surrounding the stars and seen almost edge-on.

Algol-like brightness dips are caused by a dust clumps (or/and asteroid-sized bodies), which suddenly intercepts the line of sight to the observer and obscures the stellar light. The fluctuations of temperature and IR-luminosity of the accretion disk can also play role in observed IR-variability. The kind of the observed photometric behaviour of UXors depends on an angle between a disk plane and the line of sight. In the case of disks seen almost edge-on extinction fluctuations is the most important reasons of variability in near-IR while the variability of face-on disks is due solely to variations of physical parameters of the inner disk region where a bulk of near-IR emission is generated.

Investigation of UXors in near-IR region helps to understand processes which occurs in an immediate vicinity of UXor stars.

Observations

The observations were carried out in Observatory Campo Imperatore (Italy) with Pulkovo telescope AZT-24 (1.1 m) during 2003–2017. AZT-24 is equipped by EFOSC-camera SWIRCAM with Johnson JHK bands.

Mean errors of data is ~0.01-0.02m.

Additionally to IR-observations we use optical data (band V) from photometric data-bases ASSASN-V and AAVSO (the rest – only for illustration). Optical observations of VX Cas obtained with telescope AZT-11 (Crimean Astrophysical Observatory) and data obtained in Maidanak observatory from our previous publication (2008) are appended.

Objects

Our investigation relates to two Herbig Ae/Be stars: VX Cas and V517 Cyg, referred to UX Ori stars ([1] and [2] respectively).

Both of stars demonstrate the UXor particularities: color behaviour in optic, Algol-like dips with V-band amplitudes up to 2.8^m[4] (V517 Cyg) and up to 2.0^m[3] (VX Cas), variable Hα-emission, IR-excess and a significant polariza-tion varying with brightness.

VX Cas and V517 Cyg have optical spectra features which indicate a sign of gas shell surrounding the stars. The spectra of VX Cas also show a sign of gas accretion flows.

Optical light curves of **V517 Cyg** demonstrate (**1**) a long-term cyclic trend (P~10 year), (**2**) intermediate time-scale variation with amplitude of 0.5–1^m (quasi-period $\sim 93^d$) and (**3**) rapid variability with amplitude of 0.4^m on time-scale of 12 days. All of these kind of variability are accompanied by small-scale fluctuations of 0.1^m [4–6].

There are no investigations of IR-behaviour of the star, except solitary measurements (catalogues 2MASS, WISE, MSX, IRAS, [7]) and our previous work (2008).

VX Cas is studied in more detail.

V-band variations of VX Cas occur basically within 0.5m in the bright state, with rare deep minima which can have multicomponent structure interpreted in terms of eclipses of star by complex "multi-clumps" gas-dust clouds. These minima show color-magnitude tracks which is typical for UXors and caused by increasing of scattered radiation from a circumstellar disk.

There is no reliable estimation of periodicity of optical variation, but some authors suppose a non-periodical season-to-season trends (e.g. [8]).

Several IR-studies of VX Cas were undertook (e.g. [8]). They have revealed that optical and IR-variation are correlated. This effect can be explained by optically thin halo surrounding an optically thick disk [9]. IR-variation amplitude decreases with wavelength.

Results

VX Cas

The near-IR and optical (V-band) photometry of VX Cas is shown on fig.1. It's clear that the magnitude variation of VX Cas have the close amplitude in all IR-bands, and it is smaller than optical one. On fig.1 a cyclic trend (~5 years) is seen.

The season light curve in J-band in more detail show significant changes of VX Cas radiation (fig.2).

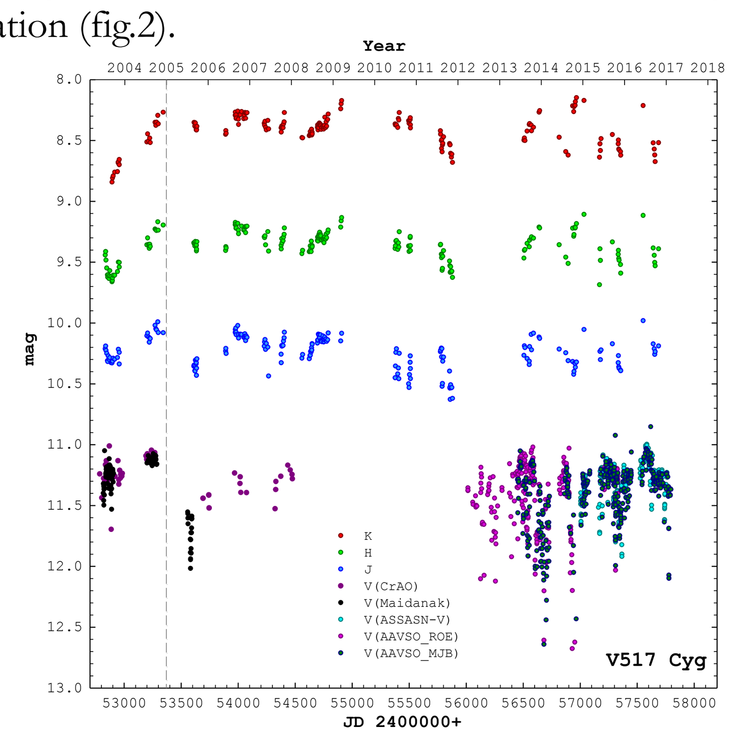

Fig.1. The light curves of VX Cas in near-IR (2003-2017) and V-band (2003-2018). The dotted line separates two observational periods with different behaviour (details see in text).

The "color-magnitude" diagram shows large dispersion. The color tracks (J-H, J) and (H-K, J) (fig.3) have an interesting detail. It is an unusual color trend observed in the first part of our observations (JD 2452838 – 2453303, red points on the fig.2 and 3). So the brightening of the star was accompanied with the reddening in J-H and H-K colors (see also fig.1).

The following seasons show the opposite regime: the IR colors become bluer with the J-magnitude increasing.

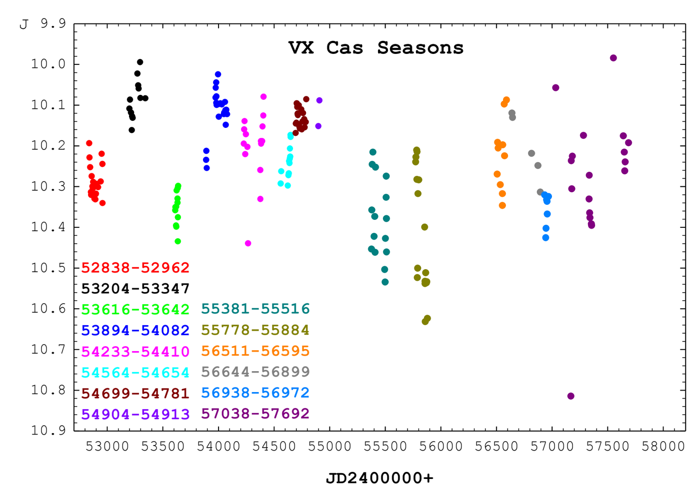

Fig.2. The season light curve of VX Cas in J-band.

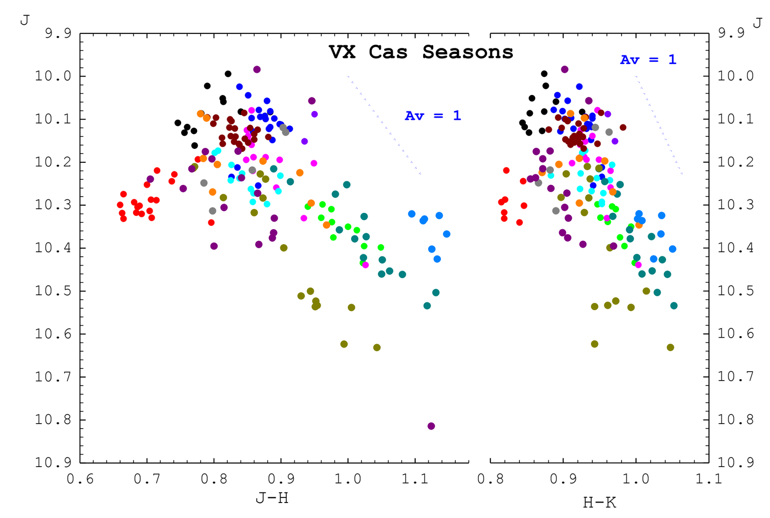

Fig.3. The season color indexes of VX Cas in near-IR. A blue dotted line corresponds to the standard extinction law.

The correlation diagram between the near-IR and optical magnitudes is presented on fig. 4. We used only measurements obtained by Maidanak observatory from our previous work because the rest datasets have small time-intersection with our IR-data.

All bands shows significant level of correlations (the Pearson's correlation coefficients are ~0.6).

A good correlation between light variations in band V and bands J, H, K seems to be regarded to relatively small gas-dust clumps of the circumstellar disc. They can completely shield the star from the observer, but can't shield the inner region of the disc (close to the dust sublimation zone), in which the bulk of the IR emission is formed [10].

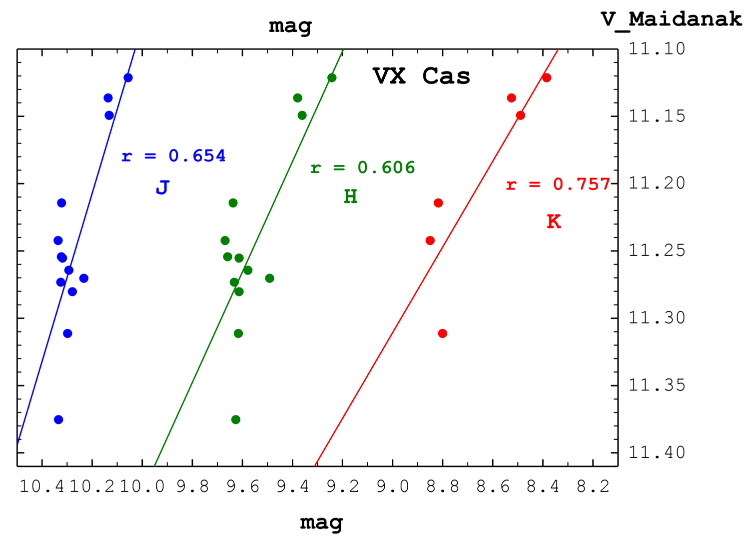

Fig.4. Correlation V-band and IR-bands for VX Cas.

V517 Cyg

The near-IR and optical light curves of V517 Cyg are given on fig.5. The clear variability with several Algol-type minima can be seen in IR-bands (see fig.6 for detailed season variability).

In contrast to VX Cas, V517 Cyg demonstrates decreasing of variations amplitude with increasing of wavelength: $\Delta J \sim 2^m$; $\Delta H \sim 1^m$, $\Delta K \sim 0.5^m$.

This can link with the circumstellar extinction variations on the line of sight. The extinction decreases with wavelength itself (selective dust absorp-tion). Moving gas-dust clouds around the central star leads to changing of the contribution of photospheric radiation to the observed flux [10].

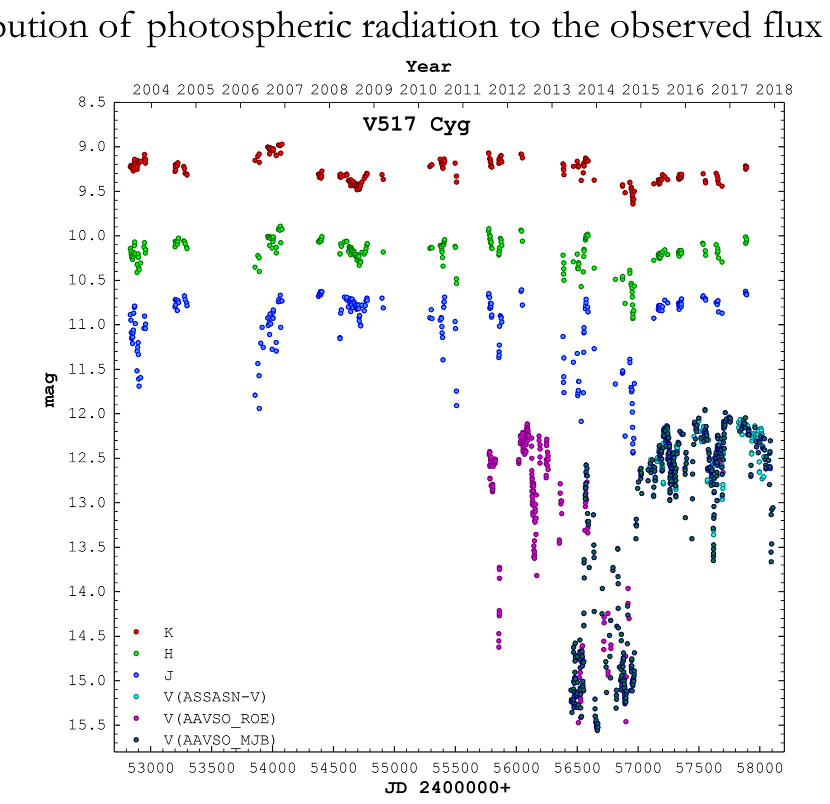

Fig.5. The light curves of V517 Cyg in near-IR (2003-2017) and V-band (2011-2018).

The behavior of color tracks (J-H, J) and (H-K, J) (fig.7) is typical for UXors (the colors increase while the star brightness fades – the star becomes redder). The color trends can be explain in term of the selective absorption of star light by the circumstellar dust particles. Difference between the color behaviour during the brightness fading and the standard extinction law is clear.

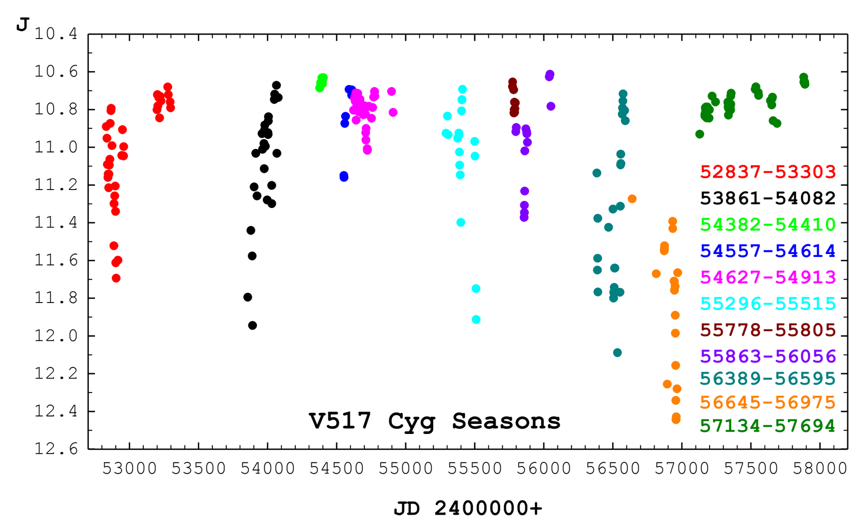

Fig.6. The season light curve of V517 Cyg in J-band.

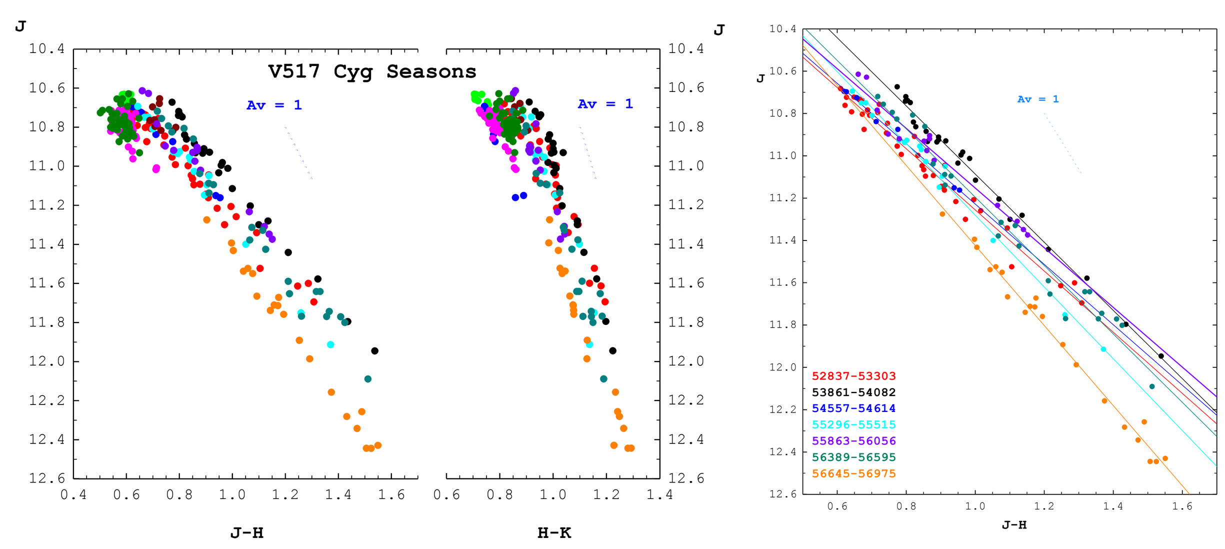

Fig.7. **Left:** The season color indexes of V517 Cyg in near-IR. A blue dotted line corresponds to the standard extinction law. **Right:** The Algol-type minima of V517 Cyg. A blue dotted line corresponds to the standard extinction law.

On the magnitude diagram (fig. 9) one can see that the IR-magnitudes correlate. The correlation coefficients equals 0.75 and 0.06 for H(J) and K(J), respectively. The last small value may be due to large dispersion of K magnitude: several trends are observed on the plot.

Our previous study based on data 2003-2008 years shows that the J and K magnitude anticorrelate, but extended observational interval discovers more complex dependence between IR-magnitude, especially for K(J).

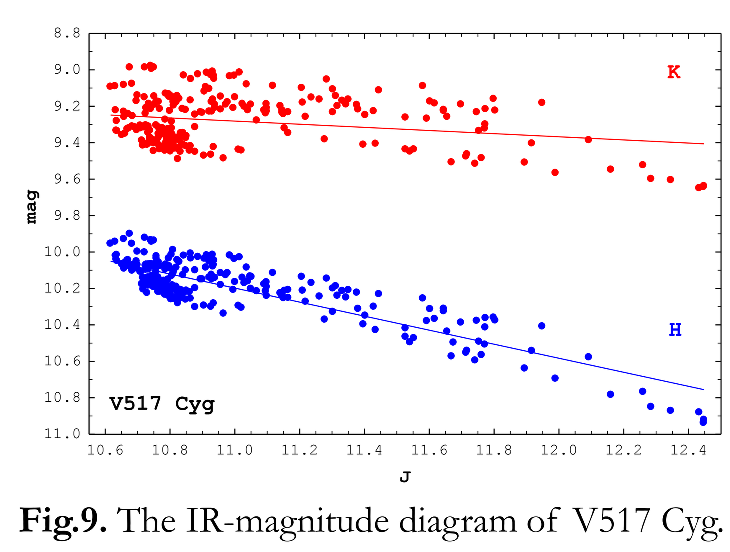

Fig.9. The IR-magnitude diagram of V517 Cyg.

Conclusion

The uniform long-term observations of VX Cas and V517 Cyg in near-IR region were carried out by using Pulkovo telescope AZT-24.

Both of stars demonstrate UXor peculiarities in near-IR light curves. The IR colors become bluer with the J-magnitude increasing, but have some observed features which is impossible to explain in the framework of the model of the self-shadowed disk [11,12].

Comparison recent work with our previous investigation based on 5-year observation dataset show that both of stars have more complicated photometric behaviour than supposed.

References

1. G. H. Herbig & K. R. Bell, 1988, Third Catalog of Emission-Line Stars of the Orion Population : 3 : 1988
2. G.W. Marcy, 1980 AJ, 85, 230
3. D. N. Shakhovskoi et al., 2003 Astron. Rep 47, 301
4. V. S. Shevchenko et al., 1993, Astrophys. and Space Science, 202, 121
5. V. S. Shevchenko et al., 1993, Astrophys. and Space Science, 202, 137
6. G. V. Abramyan et al., 1990, Ap, 32, 24
7. I. S. Glass & M. V.Penston, 1974, MNRAS, 167, 237
8. C. Eiroa et al., 2001, A&A, 365, 110
9. D. Vinković, et al, . 2006, ApJ, 636, 348
10. V. I. Shenavrin, et. al, 2012, ARep, 56, 37
11. C. P. Dullemond et al., 2003 ApJ, 594, L47
12. A. Juhász et al., 2007 MNRAS, 374, 1242