Advances in Astronomy and Space Physics, **3**, 81-83 (2013)

Long-term photopolarimetric variability of DD Ser

S. P. Belan[*], *D. N. Shakhovskoy*

Crimean Astrophysical Observatory, Nauchny, Ukraine

We present some results of UBVRI-photopolarimetric observations of DD Ser, a poorly studied and understood Ae-star. The long-term component of light variation is detected, with the period of about fifteen years. Variability of the degree and positional angle of linear polarization is observed as well. Analysis of correlation between photometric and polarimetric data shows that observed light minima are likely caused by variability of circumstellar extinction produced by dust.

Key words: stars: variables: T Tauri, Herbig Ae/Be: individual: DD Ser – stars: pre-main sequence

INTRODUCTION

The class of Herbig Ae/Be (HAeBe) stars was established by Herbig [4] as stars which are surrounded by nebulosities and the optical spectra of which show emission lines. Further investigations revealed that these sources are young stars (1–10 Myr) with masses 2–10 $M_\odot$ in the later stages of their pre-main sequence evolution. Existence of infrared emission is another characteristic of these stars. The infrared excess emission arises from a protoplanetary disk [10] and in many cases from an envelope as well [5]. HAeBe stars are, therefore, frequently regarded as the higher mass counterparts of the low-mass T Tauri stars. There is a class of objects, named UXORs, including Herbig Ae/Be and T Tauri-type stars, which is characterized by a pronounced photometric activity. The variability of these stars is caused by changes of circumstellar extinction on the line of sight [1].

Planet formation theories suggest that this evolutionary stage (1–10 Myr) is exactly where the formation of planetary embryos is likely to occur. Thus, Herbig Ae/Be stars are natural candidates for studying the physical processes playing an important role in planet formation.

DD Ser is a poorly studied and understood Ae star that shows unpredictable light fading lasting from a few days to several years with V-amplitude near 1^m [6, 9]. The star spectral classification is A5 III and absolute luminosity is $M_v = -0^m.2$ [8]. There is a variable emission in Hα-line [7]. Existence of emission and the type of photometric variability of DD Ser make it similar to Herbig Ae stars, but it was not classified so due to the lack of observed infra-red excess.

[*]sbelan17@gmail.com

OBSERVATIONS AND RESULTS

Observations of DD Ser were carried out in 1988–2013 at the Crimean Astrophysical Observatory as a part of the program of long-term photopolarimetric monitoring of young stars. All data were obtained at 1.25 m telescope with UBVRI-polarimeter. In our photometric observations a long-term component of variability is evident. It is apparently periodic, with the period of about 5500 days and amplitude about $0^m.3$ in V-band (see Fig. 1).

A correlation between polarization parameters and brightness is found in four bands (U, B, V, R) (see Figs. 3–6 and Tab. 1). Pearson correlation coefficients (R) for all bands are presented in Table 1, where the third and fourth columns are the least square fit slope and the false alarm probability of the correlation, respectively.

The character of this dependence is rather linear, unlike one typical for UXORs [1]:

$$\mathbf{P} = \mathbf{P}_{is} + \mathbf{P}_0 \cdot 2.5^{m-m_0},$$

where $\mathbf{P}$ is the pseudo-vector of observed polarization, having P_x and P_y normalized Stokes parameters as components, $\mathbf{P}_{is}$ is interstellar (constant) component of polarization, $\mathbf{P}_0$ is polarization in a certain state of brightness m_0.

Cyclic photometric activity with periods of ten-fifteen years is typical for UXORs [3]. Correlation of photometric and polarimetric data supports the idea that observed light minima are likely caused by variability of circumstellar extinction produced by dust, like in UXORs. Linear dependence of polarization on magnitude could be explained as predominance of polarization mechanism caused by absorption by aligned non-spherical dust particles over the mechanism associated with scattering. Abrupt nonlinear increase of polarization with light weakening is observed in UX Ori-type stars at the moments of deep minima ($> 2^m$). Such minima have not been observed in DD Ser, that is probably why scattering component of polarized radiation is never strong enough to dominate in observed light.

Table 1: Pearson correlation coefficients between photometric and polarimetric data for all bands.

band	R	Se	σ
U	−0.28	0.05	$4.71 \cdot 10^{-5}$
B	−0.27	0.06	$8.73 \cdot 10^{-5}$
V	−0.33	0.08	$2.87 \cdot 10^{-6}$
R	−0.29	0.1	$4.06 \cdot 10^{-5}$
I	−0.08		0.26

Based on the whole pattern of photometric and polarimetric variability one might suggest that DD Ser is a more massive analogue of RZ Psc, a transitional object slightly older than typical UXORs, with low-mass residual circumstellar dust disk [2]. Specific features common for DD Ser and RZ Psc are the absence of observable IR-excess, sharp light minima seldom (or never in case of DD Ser) reaching 1^m depth, long-term cyclic photometric variability. The best interpretation of this is a well-evolved disk with dust-free inner lobe, where compact dust clouds sporadically appear presumably as a result of destruction of solid bodies similar to comets and asteroids.

This class of rare objects with disks almost dissipated but still observable in the line-of-sight dust absorption is very important for better understanding of disk evolution and planetary system formation. That is why DD Ser deserves further thorough investigation.

REFERENCES

[1] Grinin V. P., Kiselev N. N., Chernova G. P., Minikulov N. Kh. & Voshchinnikov N. V. 1991, Ap&SS, 186, 283
[2] Grinin V. P., Potravnov I. S. & Musaev F. A. 2010, A&A, 524, A8
[3] Grinin V. P., Rostopchina A. N. & Shakhovskoi D. N. 1998, Astron. Lett., 24, 802
[4] Herbig G. H. 1960, ApJS, 4, 337
[5] Leinert Ch., Haas M., Ábrahám P. & Richichi A. 2001, A&A, 375, 927
[6] Meinunger L. 1965, Mitt. Veränderl. Sterne 3, 9
[7] Pugach A. F. & Kovalchuk G. U. 1999, A&A, 347, 937
[8] Timoshenko L. V. 1984, Astrofizika, 21, 314
[9] Tsesevich V. P., Dragomiretskaya B. A. & Bogorodskij A. F. 1973, Naukova Dumka, Kyiv
[10] Waters L. B. F. M. & Waelkens C. 1998, ARA&A, 36, 233

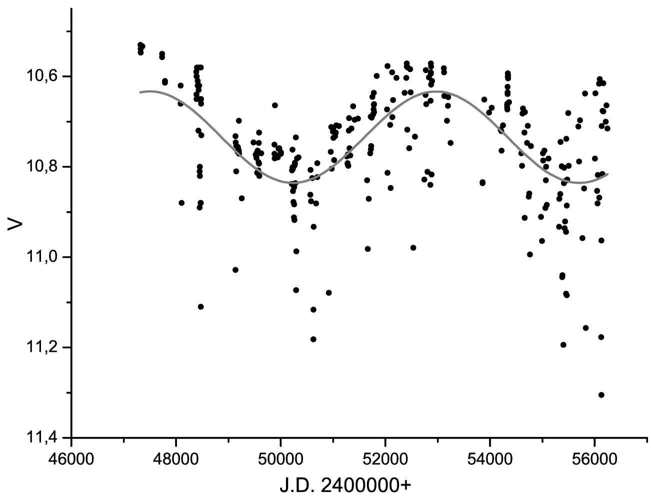

Fig. 1: The lightcurve of DD Ser (gray line is the least square fit of 5500 days period).

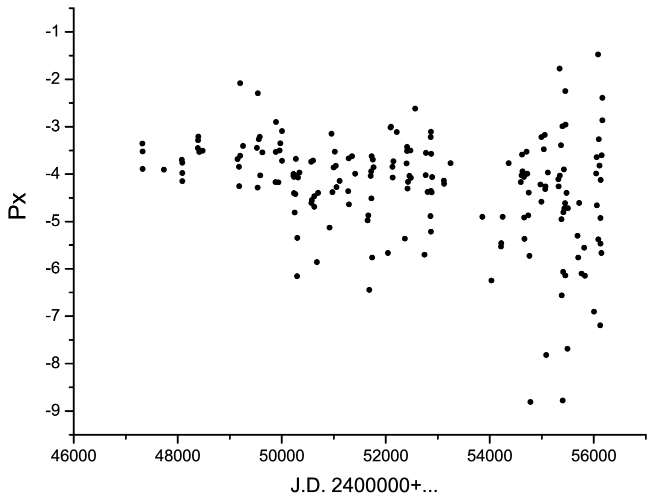

Fig. 2: Variability of P_x component of polarization.

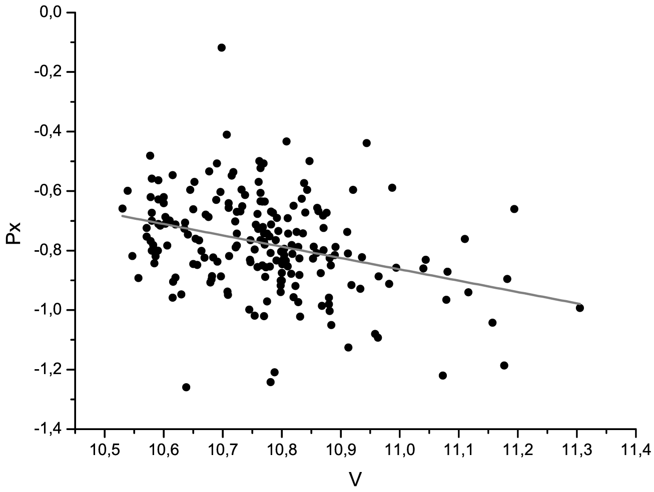

Fig. 3: Dependence of polarization on brightness (V).

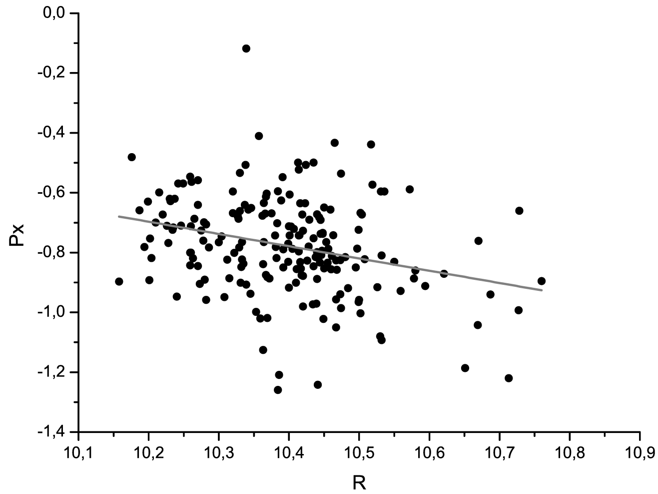

Fig. 4: Dependence of polarization on brightness (R).

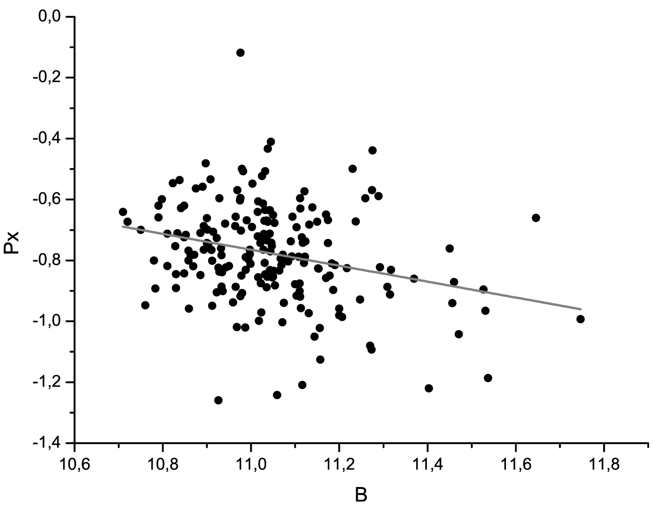

Fig. 5: Dependence of polarization on brightness (B).

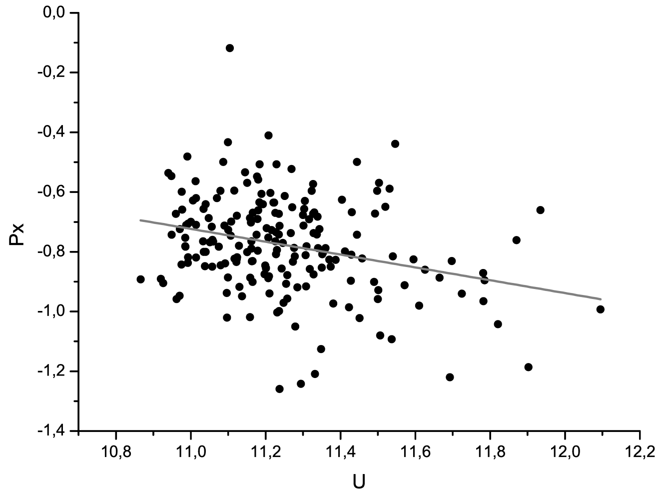

Fig. 6: Dependence of polarization on brightness (U).