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SOME CHARACTERISTICS OF INTRINSIC POLARIZATION OF Be STAR κ Dra

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Abstract. The intrinsic polarization parameters of κ Dra in V-color measured at Belgrade Observatory during the 14 years period (1979-1992) are presented. The changes of polarization percentage are discussed with the data of V-color photometry and Hα emission line equivalent widths.

1. INTRODUCTION

Rapidly rotating B stars with temporary hydrogen emission are known as Be stars since 1931 (Struve, 1931). These stars may throw off matter at their equatorial edges forming disk-like envelopes. Although a great number of well organized investigations in wide range of the electromagnetic spectrum exists, we are still far from understanding the phase change B to Be. Good example is the star κ Dra (HD 109387) of the spectral type B6 IIIpe and projected rotational velocity $V \sin i$ =200 km/s (Hirata, 1994). Balmer emission of this star was already discovered in 1890 by Pickering. During almost two last decades various systematic polarimetric, photometric and spectroscopic investigations have been done. In spite of that, many questions stay still open . In this paper, on the basis of some existing observations of the star κ Dra we will try to formulate the most interesting questions.

2. OBSERVATIONS

2. 1. POLARIZATION

Polarimetric observations at Belgrade Observatory from 1974 till 1992 were carried out with the 65-cm Zeiss refractor and the stellar polarimeter (Kubičela *et al.*, 1976), which was modified in 1979 to enable one to obtain digital magnetic records suitable for further computer processing. The measurements were done in the V spectral region. Integration of the raw polarimetric signal was done in 4-second intervals. The angular velocity of the analyzer was one turn per minute. In most cases under "one measurement" we understand up to 8 one-minute polarimetric sine-wave signals phase-averaged. The typical standard deviation of one 8 minute individual measurement is 0.07% for Stokes parameters Q and U.

The complete revision of the system constants was carried out for the observations till 1990 with all standard stars. The consequences of this revision are the small changes of the system constants and calculated polarization parameters published before 1990.

In determination of the intrinsic polarization the interstellar components were estimated or used from the literature. For the star κ Dra the procedure of evaluating of the interstellar component is thoroughly described in Arsenijević *et al.* (1986).

Polarimetric data presented in Figure 1 cover the period of 14 years (1979 - 1992) when the annual mean values of the intrinsic polarization percentage change from 0.15% in 1980 to 0.54% in 1985. After 1985 polarization percentage decreases till 1991. It seems that during 1992 started the new period of increasing polarization percentage. But the minimum value is higher than the values during 1980 - 1981.

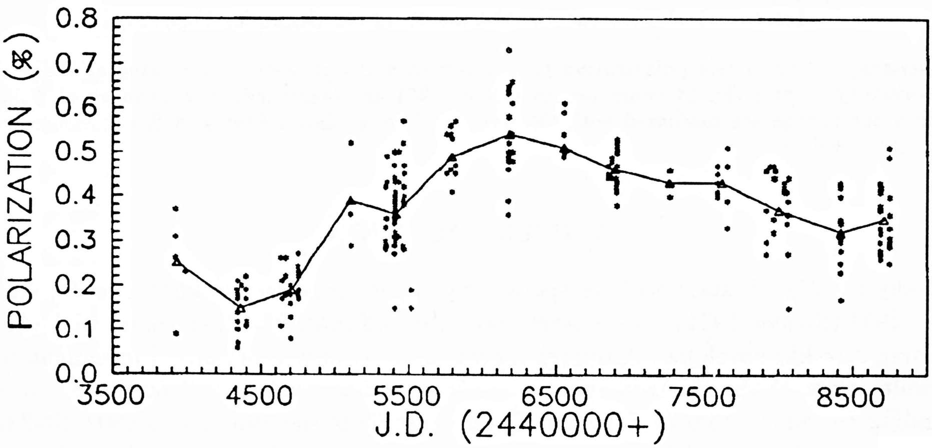

Fig. 1. **Intrinsic polarization percentage of the star κ Dra in V-spectral region.**

The existence of the intrinsic polarization means the existence of the sufficient electron density in the region of the envelope below the H_α emitting layer. According to the polarization variation in Q,U plane Arsenijević *et al.* (1994) have found that the region of the envelope responsible for the polarization has an axial symmetry. The individual polarization percentage increased during 1979 - 1986 by a factor of about 5 - 6. In annual mean values this factor is about 3.6. For the moment, the main thing is to point out that the intrinsic polarization reflects directly the state of the lower part of the envelope. So, the changes of the intrinsic polarization reflect the changes of the envelope shape and electron density.

2. 2. EQUIVALENT WIDTH OF H_α EMISSION

Figure 2. taken from the article of Yuza *et al.* (1993) shows H_α emission line equivalent width and its change practically simultaneously observed as the polarization. This emission comes from a large emitting volume, extended cool outer atmosphere. Over the interval of time 1979 - 1986, the equivalent width of H_α emission line increased by the factor of about 3 (Arsenijević *et al.*, 1994). This long-term variable and extended emitting part of the envelope gives the information on the formation and the distruction of the envelope. Using Dasch *et al.* (1992) statistical relation, the effective emitting envelope is found to have increased from 4 to 6.5 stellar radii.

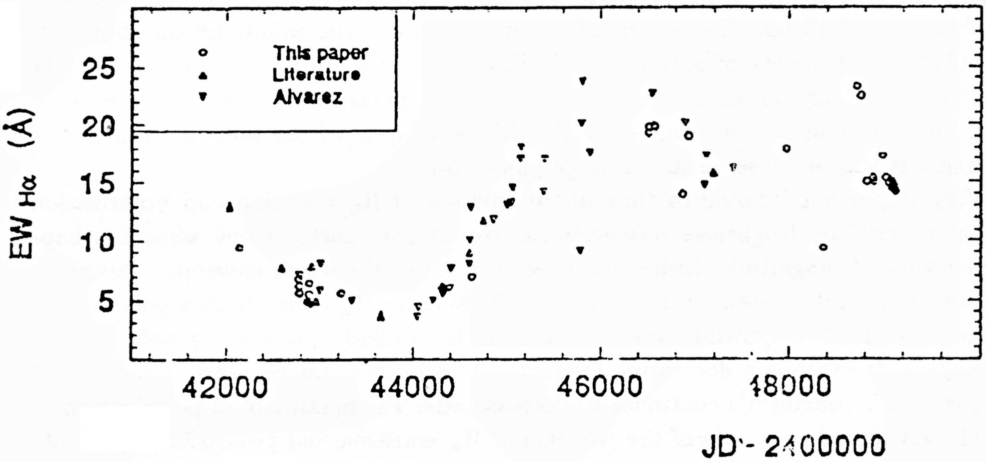

Fig. 2. The change of the equivalent width of H_α emission of the star κ Dra (from Yuza *et al.*, 1993).

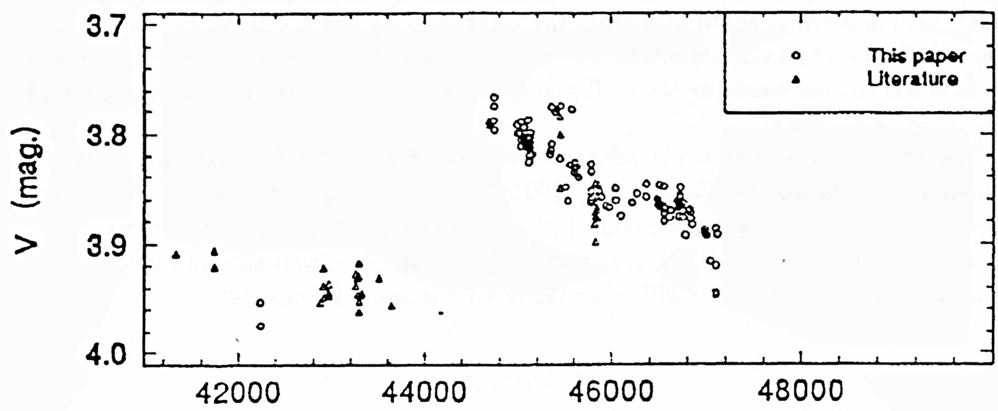

Fig. 3. Light changes of the star κ Dra (from Yuza *et al.*, 1993).

2. 3. V-COLOR PHOTOMETRY

The light curve in Figure 3, taken from Yuza *et al.* (1993), shows, according to Hirata (1994) a steep brightening and subsequent gradual decline. Traditionally, the photometric variations are attributed to the variation in the envelope of the star, but Hirata (1994) concluded that the steep brightening of κ Dra has originated not in the envelope but in the stellar photosphere. There are no observations in the interval of time that can allow us to determine the beginning of the brightening. Thus, nobody can say now which part of the star is responsible for the brightness variation.

3. ANALYSIS

The estimated moment of the minimum of the equivalent width of H_α emission is about JD 2443500. The polarization percentage has the minimum on about JD 2444350. The time lag of polarization is about 850 days. But, the emission activity started, roughly speaking, about 400 days before the polarimetric one. Both, the emission and the polarization come from the different layers of the same envelope. The question is why we observe such a large phase shift.

Very important interval of time about minima of H_α emission and polarization is not covered by brightness observations. We do not exactly know what has happened with V magnitude during the time interval of the small envelope activity in H_α emission. But, it seems that during small values of H_α emission and polarization percentage the V magnitude was high. During the period of increasing polarization, V magnitude exhibits a decreasing tendency. This is usual for Be stars. The unusual fact is that V magnitude continues to decrease after the maximum of polarization.

The estimated moments of the maxima of H_α emission and polarization percentage happened respectively on JD 2446400 and JD 2446500 approximatelly. The delay of the polarization maxima is about three months. We can say that the emission maximum at H_α coincides with the maximum of the intrinsic polarization. If these quantities are the tracers of the envelope formation and the destruction after maxima of polarization and emission, starts the envelope destruction. Why V magnitude continues to decrease? For the moment, we have in mind a very high electron density as an explanation. It could attenuate the brightness by scattering and diminish also the polarization by multiple scattering independently of the envelope geometry and in spite of the envelope staying large. This presumption is supported by the very gradual H_α emission decrease.

The long-term variation periodicity of about 23 years for V magnitude and H_α emission is confirmed by Yuza *et al.* (1993). It would be very interesting to point out here that the period of polarization percentage change is approximately two times smaller, about 11 years. Of course, this is valid if the observed second maximum of polarization on JD 2447960 will be confirmed by more observations.

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