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POLARIMETRIC OBSERVATIONS OF 44ι BOOTES

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Abstract. Linear optical observed polarization of visual binary 44ι Boo was measured with the Belgrade polarimeter in the period 1983-1990. The aim of the polarimetric observations was the investigation of possible polarization changes that are correlated with $\sim 0.^d2678$ photometric change. The star has high galactic latitude (b=70°) and very possibly zero interstellar polarization what would lead to the observed polaric being equal to the intrinsic one. Detected polarization could be interpreted as due to scattering in circumstellar envelopes. Time variation, if detected, may lead to some important conclusions about geometry of the system.

The polarization percentage ranges between 0.01% and 0.19% and polarization angles take almost all values between 0 and 180 degrees. Fourier analysis of polarization percentage data fails to give clear evidence of time dependent polarization. On the other side, statistical test (Pfeiffer, 1977.) for Q and U Stokes parameters leads to strong time variation of parameter Q, but not for U.

1. INTRODUCTION

The system 44ι Bootes ABC is the well known as a visual binary ADS 9494 with orbital period $\sim$ 225 years (Hill *et al.* 1989). 44 ι Boo BC (HD 133640, V=5.^{m}8 to 6^m, MK G2V+G) is our closest W UMa neighbour. The eclipsing period is $\sim$0.2678 days with possible period changes and various analyses (Bergeat *et al.* 1972, Duerbeck, 1978, Hill *et al.* 1989 and references therein) yielded some contradictory results. For example Duerbeck (1978) claimed no period changes between 1968. and 1977, contrary to the conclusions of two other papers. From recently detailed analysis of Hill *et al.* (1989) it is clear that there were several small period changes between 1920. and 1985. and we accepted their result because *rms* of each fit is gratifyingly small (less than 0.003 days) and the rate of change of the period is free of the light-time effects that vitiate some earlier spurious estimates. The light-curve analysis (in U, B and V) is also difficult, due to light contribution of the brighter visual component A. Brightness variation of the variable (44ι Boo BC) was only 0.^{m}17 in blue between primary minimum and primary maximum (Al-Naimiy *et al.* 1989).

Intrinsic linear polarization is now well established as due to scattering from circumstellar material in the majority of cases (Zellner and Serkowski 1972). After polarization observations of 17 eclipsing variables, between few possible mechanisms of the origin of polarization of the radiation of close binary systems, the scattering of the light of the star in a gas envelope is found as most effective – if a star has an envelope (Shakhovskoj, 1964).

Unfortunately, polarimetric observations of 44ι Boo were rare and uncompleted, those of Pfeiffer (1977) being an example. In our measurements it was not possible to separate brighter component of the system 44ι Boo A from our variable 44ι Boo BC, what might cause uncertain amount of depolarization of light from the star, but did not have any influence on time-variability of polarization. According to Duerbeck (1978) minor time-dependent irregularities of the light curves may be interpreted as the presence of circumstellar matter that causes absorption effects at phases 0.125, 0.375, 0.625 and 0.875.

2. OBSERVATIONS

The observations have been carried out with the Zeiss refractor of 65cm aperture, in the visual spectral domain V, using the Belgrade Observatory's polarimeter. Any individual measurement is a result of a 8-minute integration of photoelectric signal modulated by a continuously rotating polaroid, its full turn taking 1 minute. During the entire time period the characteristics of the instrument and the polarimeter were controlled on the basis of observation of polarimetric standard star. Total of 166 observations were obtained between years 1983. and 1990.

In Figure 1. the polarization percent versus time in JD is given. It is obvious that in years 1983. and 1990. (JD 2445402.653 and JD 2448122.362) about 87.5% of observations were taken.

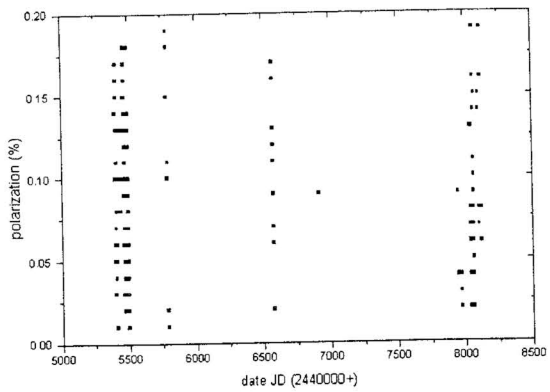

Fig. 1. The observed polarization percentage of 44ι Boo BC in V filter in the period 1983-1990.

In Figure 2. variation of polarization angle is given. Stokes parameters U versus Q are plotted in Figure 3.

3. ANALYSES

For reducing the observations to the same phase we adopted the ephemeris from Hill et al. (1989):
Primary minimum: $J.D.hel.\ 2442450.5734 + 0.26780761E$.

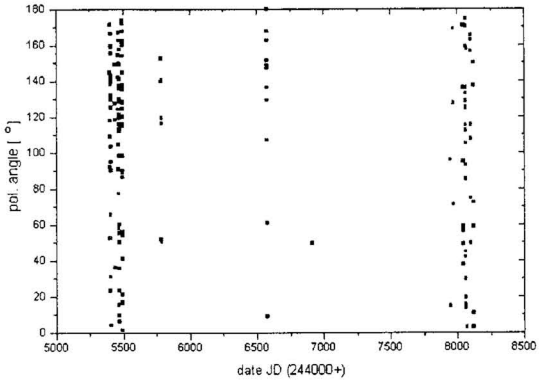

Fig. 2. The position angle of the observed polarization of 44ι Boo BC in V filter in the period 1983-1990.

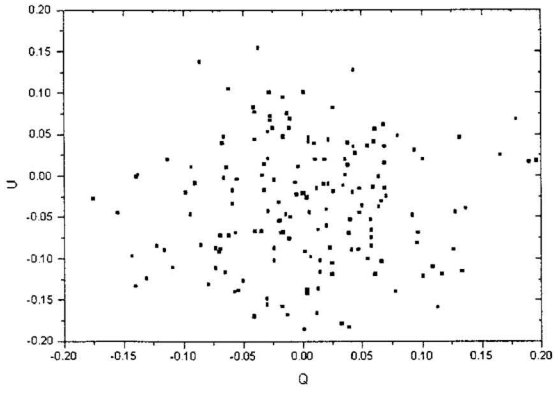

Fig. 3. The observed polarization Stokes parameters Q and U of 44ι Boo BC in the period 1983-1990.

Because of the small period, heliocentric correction of the observation time was done.

Although the obtained distribution may seem almost random, small periodic changes can be noted. The result of averaging data across 0.02 phase (approximately 8 minutes what is the integration period in Belgrade polarimeter) is shown in Figure 4. A free hand curve may be drawn and it exhibits a small sinusoidal change with an amplitude of only 0.024%. Polynomial approximation leads to a third degree polynom which has acceptable residuals (solid curve in Figure 4).

Fourier analysis of the data was done using the program package of MUFRAN ('MUlty FRequency ANalyse', Kolláth, 1990.) that deals with unequally spaced, gapped data. The Fourier spectrum shows plenty of peaks, but almost none has been enough high to be considered for further analysis. A proper check especially for frequencies that may lead to photometric (Duerbeck, 1978) and also polarization percentage change was done. Unfortunately, least square method used to find best

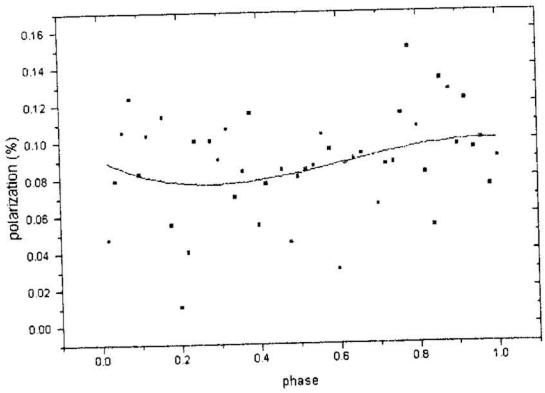

Fig. 4. The observed polarization percentage of 44ι Boo BC in V filter averaged across 0.02 phase.

fit parameters (amplitude and phase) for those frequencies gave too small level of significance.

To avoid different observational data quality, days with more observations were analyzed. The existence of time-dependent polarization can be established for a set of observations by a statistical test. In this research, a chi-squared test has been used (Pfeiffer, 1977). This test compares the scatter from the mean values of the observed polarization for a program star with the scatter from the corresponding mean values for a group of control stars. The control stars were both unpolarized and polarized standards from the list of Astronomical Observatory Polarimetric Standards.

The χ^2 test has been applied to the mean values of the Q and U parameters for each measurement. This choice of parameters is preferred since Q and U emerge directly from the least-squares reduction of the measurements which comprise an observation. A probability greater than 0.99 is regarded as definite evidence for the existence of time variation in polarization.

The results indicate that there is high probability that the Q parameter is time dependent, but less evidence exists for time dependence of the U parameter.

According to Pfeiffer (1977) no time dependent polarization is found, with the remark that there were too few observations and phase coverage was too sparse to make any definite conclusions. Compared with his data, our data set is more complete and we believe there is a good evidence for time-dependent polarization of this star.

4. CONCLUSIONS

Close binary 44ι Boo BC, the member of 44ι Boo ABC triple system was observed with Belgrade Observatory's polarimeter between years 1983. and 1990. Detected polarization (percents range between 0.01% and 0.19%) is possibly due to scattering of star light in the stellar envelope. Fourier analysis of the present data can not lead to significant polarization percentage changes with period of $\approx 0.^d2678$ neither $\approx 0.^d033$, $\approx 0.^d100$, $\approx 0.^d167$ or $\approx 0.^d234$ (Duerbeck, 1978). On the other side, Pfeiffer's,

statistical test (1977) established a strong evidence for time-dependent variation of Stokes parameters. We may conclude, based on our data analysis, that there is a high probability for time-dependent variation of the observed polarization. Only new observations, of better quality, may give a definite answer.

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