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33 Lib is an analogue of Gamma Equulei?

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Abstract. In this paper we investigate the periodic variability of the magnetic field of the magnetic Ap star 33 Lib. The period of 83.5 years found by us earlier from the magnetic field estimates and 79.2 years determined later are close to the period of variability of the magnetic field of the known Ap star γ Equ of 97 years. Such a slow rotation is also confirmed by a very small value of the projection of the equatorial velocity onto the line of sight $v_e \sin i = 0.6$ km/s.

Keywords: stars: magnetic field; individual: 33 Lib

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1 Introduction

The magnetic field of the Ap star 33 Lib (HD 137949) was first discovered by Babcock (1958). The variability of the magnetic field of 33 Lib was first studied by van den Heuvel (1971). In this work, based on a small number of the magnetic field (MF) estimates, the variability period was supposedly $18\overset{d}{.}4$. Further, Wolff (1975a) also based on MF, the periods of $23\overset{d}{.}26$ and $7\overset{d}{.}194$ were found. The most recent estimate of the period by Romanyuk et al. (2014) is $7\overset{d}{.}0187$. Attempts to detect the variability of brightness and color of this star were made by Wolff (1975b); Deul & van Genderen (1983) and a number of others were unsuccessful. The researchers recorded the absence of variability of brightness with the accuracy of about $0\overset{m}{.}01$. For the first time, weak photometric variability with a period of $4\overset{d}{.}8511$ was recorded by Wraigh et al. (2012) using the data obtained on the STEREO satellite (NASA) observations (Eyles et al. 2009).

Kurtz (1982) discovered rapid photometric variability of this star with the period of 8.2721 minutes. This discovery greatly strengthened the analogy with another very well-known magnetic Ap star γ Equ—the presence of a strong global magnetic field, rapid photometric variability and unusually long rotation periods. Ap stars provide a unique opportunity to unambiguously estimate the rotation periods of stars, as well as the angles of inclination of the rotation axes to the line of sight, etc. Thanks to this, amazing objects were discovered— "standing" stars, the rotation periods of which are decades and can even reach hundreds and even thousands of years, as indicated by Mathys (2017). This is confirmed in the works of Metlova et al. (2014); Bychkov et al. (2016); Hubrig et al. (2018); Giarrusso et al. (2022) and others. The study of long-period variability is always associated with a number of obvious difficulties: it is difficult to obtain a homogeneous series of measurements over tens of years.

2 Analysis of observational data

The probable magnetic period of this star was previously estimated at 83.5 years (30478^{d}) (Bychkov et. al. 2015) based on 21 B_l estimates obtained over about 21 years. This estimate is close to the estimate obtained later by Giarrusso et al. (2022) based on a larger volume of observational material based on 77 B_s estimates obtained over 29 and 79.2 years (28902^{d}). Using this period estimate, we will construct the average magnetic phase curves (MPC) based on the estimates of B_l and B_s, and also obtain the parameters of this variability. These MPCs are presented in Fig. 1a, b respectively.

Another indirect proof of such a slow rotation is the determination of the projection of the equatorial rotation velocity on the line of sight $v_e \sin i$. Such precise

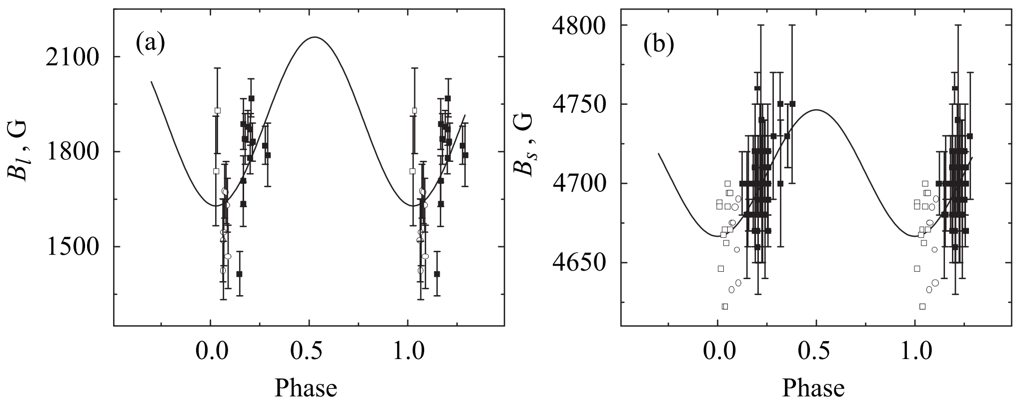

Fig. 1. Average magnetic phase curve obtained from B_l (a) and B_s (b) estimates.

determinations for magnetic stars can be made only by the lines not subject to magnetic broadening. Such lines are the iron lines Fe I λ5434.524, λ5576.089. The spectral regions near these lines were obtained with a resolution of $R = 80\,000$ on the UVES spectrometer (VLT UT2 ESO Paranal telescope). Fitting both lines yields $v_e \sin i = 0.6$ km/s, i.e. the rotation is very slow, almost like that of γ Equ. Fig. 2 shows, as an example, a spectrum region in the region of Fe I λ5434.524. The value of the obtained estimate is limited from above by the spectral resolution of the spectral material used.

3 The discussion of the results and conclusion

At present we have the following observational facts:

1. The projection of the equatorial rotation velocity $v_e \sin i = 0.6$ km/s, i.e. is actually close to zero. This fact can be explained either by extremely slow rotation ($P = 79.2$ years), or the angle i being close to zero, i.e. the axis of rotation of the star is directed towards us.
2. It is unlikely, but possible, that the rotation axis precesses with such a long period. Critical observations for testing both possible scenarios will be polarimetric monitoring of these objects. This will allow us, as in the case of γ Equ (HD 201601) (Leroy et al. 1994; Bychkov et al. 2016) to say unequivocally whether such a long period is the rotation period of the star or it can be explained in some other way.

Unfortunately, at the moment we have a series of estimates covering only a small part of the expected period, no more than 37%. We hope to increase the duration of the observation series in the near future, which will allow us to obtain a more accurate estimate of the period and the parameters of magnetic field variability.

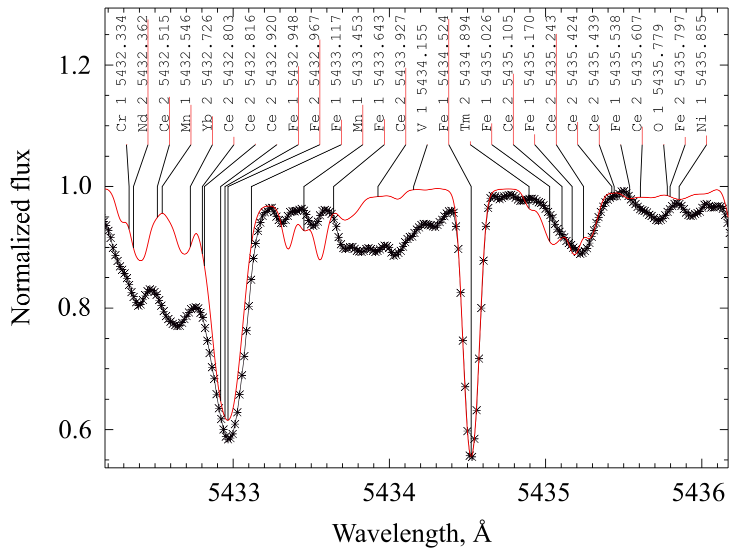

Fig. 2. The spectrum section near the Fe I λ5434.524 line. The line shows the observed spectrum, the asterisks are the results of the synthetic spectrum calculation.

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