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Averaged magnetic phase curves. Analysis of the catalog

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Abstract. We analyze parameters of the averaged phase curves of the effective magnetic field B_e for 139 main sequence and other stars. Most of them, 134 objects, are chemically peculiar A and B type stars. This contribution presents statistical properties of fitting coefficients B_0, B_1, and B_2, and the distribution of the parameter $r = B_e(\max)/B_e(\min)$.

1 Introduction

We have selected all individual measurements of the effective magnetic field B_e, which have been published over the recent 50 years, and have made a catalog of magnetic phase curves $B_e(\phi)$ for the stars which exhibit periodic variability of B_e with the rotational phase ϕ. A total of 139 stars are included in the catalog, 134 of them being Ap stars (Bychkov et al., in preparation).

Most of the stars collected in the catalog exhibit periodic B_e variations which can be satisfactorily approximated by a simple sine wave (first order term in the harmonic expansion). In some cases, this is due to scarce or inaccurate B_e observations. However, 18 stars distinctly exhibit more complex $B_e(\phi)$ curves, which we have also fitted using the second order harmonic term (double wave). The latter group of stars accounts for about 13 % of our sample.

The above number, 13 %, is the lower limit which may increase in the future when new averaged phase curves $B_e(\phi)$ of higher accuracy become available.

The catalog presents 166 various magnetic phase curves. This is due to the fact that magnetic stars sometimes exhibit quantitatively different phase curves when B_e were measured by different methods or in different spectral lines.

2 Magnetic variability parameters

Fig.1 shows the number distribution of the cataloged stars vs. coefficient B_0 for those stars in which phase curve $B_e(\phi)$ was approximated by a sine wave. Fig.1 does not include HD 215441 with its exceptionally strong B_e field since this single point exceeds the scale bounds of the Figure. The average value of B_0 over all single-wave stars equals 21 ± 138 G, the latter value representing the broadening of the peak, rather than the error.

Fig.2 displays a similar number distribution of the cataloged stars vs. coefficient B_1 (half-amplitude of B_e variability). This figure also shows only the stars which exhibit a sine wave $B_e(\phi)$.

It can readily be noted, that there exists huge deficiency of stars with small half-amplitudes B_1 of the effective magnetic field variations, see Fig.2. In the oblique rotator model the constancy or low B_e variations

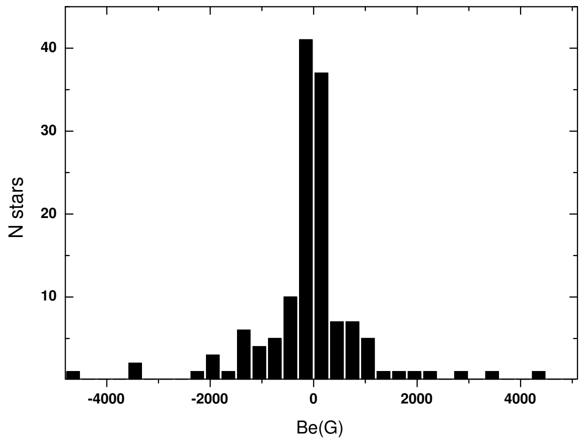

Figure 1: *Number distribution of cataloged stars vs. coefficient B_0 for those stars for which phase curve $B_e(\phi)$ was approximated by a sine wave.*

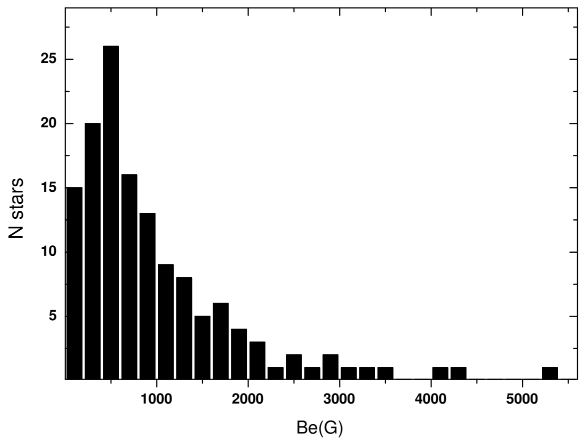

Figure 2: *Number distribution of cataloged stars vs. coefficient B_1 (half-amplitude of B_e variability). This figure also shows only those stars which exhibit a sine wave phase function.*

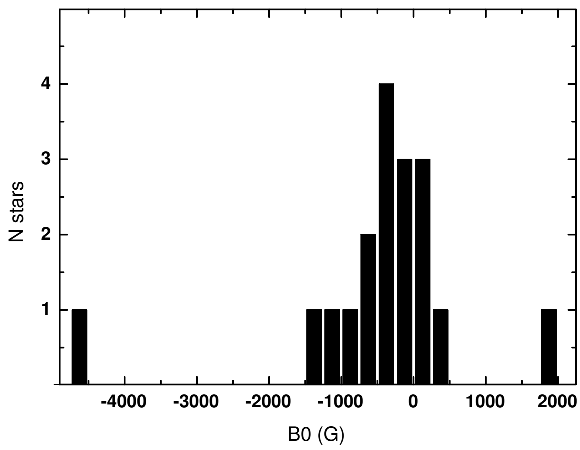

Figure 3: Number distribution of stars vs. coeffcient B_0 for those stars which exhibit a magnetic phase curve with a double wave.

of a magnetic star can occur if the angle β between the magnetic and rotational axes is small or even zero. I.e. this observation suggests that magnetic stars avoid configurations with a small angle β.

Fig.3 shows the number distribution of stars vs. coeffcient B_0 for those stars which exhibit a magnetic phase curve with a double wave. The average value of B_0 equals -473 ± 296 G. Again, the value of 296 G represents the broadening of the peak distribution. The total number of stars which make up the figure is small (18 objects), therefore statistics is poor. However, we conclude that stars which show complex B_e phase curves (double waves) more frequently exhibit negative values of B_e.

3 Distribution of periods

Fig.4 presents the distribution of stars in our catalog vs. decimal logarithm of period P, separately for all Ap stars with known periods (upper panel), and for stars with known phase curves (lower panel). The width of a single bin equals 0.3 dex.

Approximately 60 % of all Ap stars have their periods P between 1 and 5 days. The same is true for stars with known phase curves.

4 Distribution of the parameter r

The parameter r puts constraints on the angle β between the magnetic dipole axis and the rotation axis and the angle i between the rotation axis and the line of sight (Stibbs 1950)

$$r = \frac{\cos\beta\cos i - \sin\beta\sin i}{\cos\beta\cos i + \sin\beta\sin i}\,. \tag{1}$$

One can express this parameter by observed quantities

$$r = \frac{B_e(\min)}{B_e(\max)}\,. \tag{2}$$

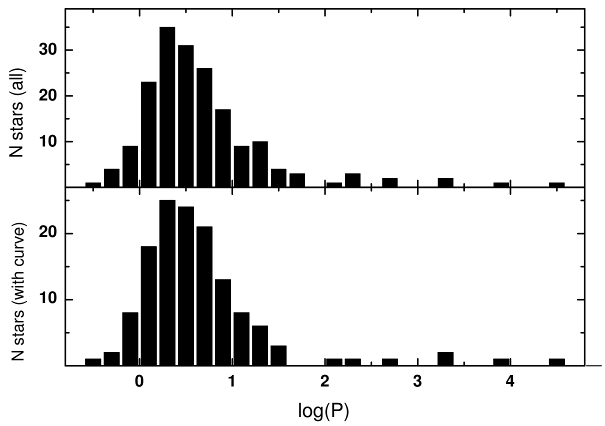

Figure 4: *Number distribution of stars in our catalog vs. decimal logarithm of period P, for all Ap stars with known periods (upper panel), and for stars with known phase curves (lower panel).*

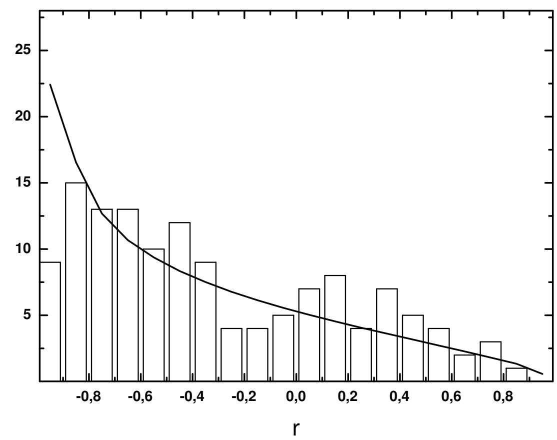

Figure 5: *Measured distribution of the parameter r vs. theoretical distribution, the latter corresponding to the random stratification of β and i angles.*

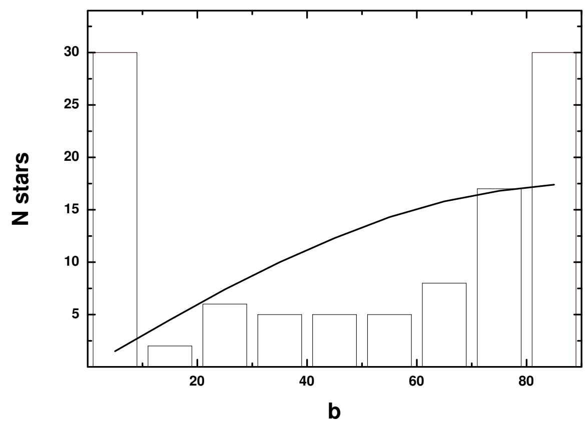

Figure 6: *Number distribution of stars in our catalogue vs. the angle β between magnetic and rotational axes.*

Fig.5 presents the number distribution of stars in our catalog vs. the observed parameter r (the histogram). The solid line shows the theoretical distribution obtained under an arbitrary assumption that the angle β is distributed uniformly. One can see that the figure demonstrates substantial differences between the observed and theoretical distributions of the parameter r.

Finally, we attempted to collect or recompute the number distribution of the angle β itself in the group of cataloged stars, based on our collection of phase curves $B_e(\phi)$. Such a distribution is shown in Fig.6. Note that there exists an excess number of stars with the angle $\beta \to 0$, which contradicts the previous results obtained (Fig. 2).

5 Summary

We have collected in a single cataloge all the available magnetic phase curves $B_e(\phi)$ and expressed them in the uniform manner. The catalog lists phase curves for 139 stars, 134 of them are magnetic Ap stars. Such a catalog allowed us to list all the parameters of stellar magnetic variations and perform homogeneous analysis of these data.

We note the apparent deficiency of stars with small variations of B_e, see Fig.2. We also conclude that there exists deficiency of stars with the lowest and intermediate values of the parameter r, i.e. in particular, at the limit $r \to -1$, as compared with the theoretical model of uniform distribution of the angle β.

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References

Bychkov V.D., Bychkova L.V., Madej J., in preparation
Stibbs D.W., 1950, Mon. Not. R. Astron. Soc., 110, 395