Magnetic Fields throughout Stellar Evolution
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Magnetic fields of OB stars

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Abstract. We studied the statistical properties of the magnetic fields of OB stars based on the recent measurements. As the statistically significant characteristic of the magnetic field we use the *rms* magnetic field of the star $\mathcal{B}$. The distribution functions $f(\mathcal{B})$ of magnetic fields of OB stars are evaluated. The function $f(\mathcal{B})$ has a power-law dependence on the $\mathcal{B}$ with an index of about 2-3 and a fast drop below $\mathcal{B} = 100 - 300$ G. We proposed that the compact regions with strong local magnetic fields can contribute to the global magnetic field of O stars.

Keywords. stars: magnetic fields – stars: early-type – stars: spots

1. Introduction

At the present time magnetic fields of more than 1000 stars have been detected (Bychkov *et al.* 2009). In order to improve our understanding the nature of the stellar magnetic fields, we investigate the sample of OB stars with measured magnetic fields. As a statistical measure of the magnetic field value we use the root-mean-square (*rms*) magnetic field

$$\mathcal{B} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(B_l^i)^2}\,, \tag{1.1}$$

where we summarize all measured values of effective magnetic fields B_l^i. Here n is a number of observations. Kholtygin *et al.* (2010) showed that the *rms* field $\mathcal{B}$ depends weakly on the random values of the stellar rotational phase ϕ during the observations.

2. Results

Our sample of the magnetic fields for OB stars consists of the data presented in the catalogue by Bychkov *et al.* (2009) and new data including our recent measurements (Hubrig *et al.* 2011, 2013). Complete list of the references is given in our Stellar Magnetic Fields (SMF) project page (http://smf.astro.spbu.ru/). The mean values of magnetic fields, $B_{\rm mean}$, calculated for stars of different spectral types with measured magnetic fields are presented in Fig 1 (left panel).

We analyse the magnetic field distribution function (MFDF) $f(\mathcal{B})$ for all O and B magnetic stars, which can be determined via the following relation: $N(\mathcal{B}, \mathcal{B}+\Delta\mathcal{B}) \approx N f(\mathcal{B})\Delta\mathcal{B}$. Here $N(\mathcal{B}, \mathcal{B}+\Delta\mathcal{B})$ is the number of stars in the interval of the *rms* magnetic fields $(\mathcal{B}, \mathcal{B}+\Delta\mathcal{B})$ and N is the total number of stars with measured field.

The function $f(\mathcal{B})$ for $\mathcal{B} \geqslant \mathcal{B}^{\rm th}$ can be fitted with a power law:

$$f(\mathcal{B}) = A_0\left(\mathcal{B}/\mathcal{B}_0\right)^{\gamma}\,, \tag{2.1}$$

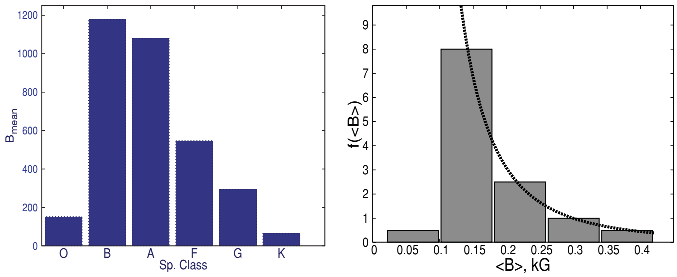

Figure 1. Left panel: Mean magnetic fields for stars of different spectral classes. **Right panel:** Magnetic field distribution function for O stars.

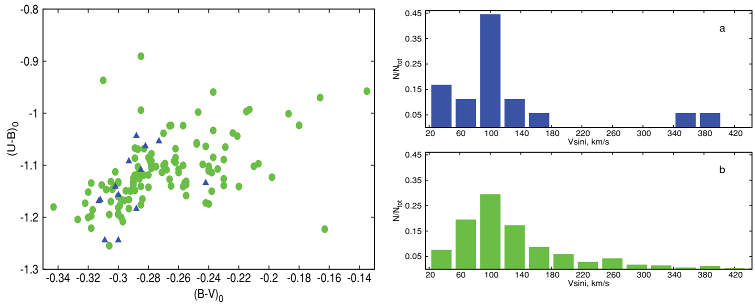

Figure 2. Left panel: Two color diagram for O stars with measured magnetic fields (blue triangles) and with no magnetic fields (green circles). **Right panel:** Distribution of the rotation velocities for magnetic O stars (top) and non-magnetic stars (bottom).

where $\mathcal{B}^{\rm th}$ is a threshold value of the *rms* field, $\mathcal{B}_0 = 1\,$kG. MFDF for O stars is shown in Fig 1 (right panel). The value of $\mathcal{B}^{\rm th}$ is 100 G for O stars and 300 G for B stars. Parameters of the $f(\mathcal{B})$ function are the following: $A_0 = 0.035$, $\gamma = -2.78$ for O stars and $A_0 = 0.34$, $\gamma = -2.09$ for B stars. We can conclude that the distribution of the *rms* mean magnetic fields of OB stars can be described by the power law for $\mathcal{B} > \mathcal{B}^{\rm th}$. The lower value of $\mathcal{B}^{\rm th} = 100\,$G for O stars can be connected with the contribution of the local magnetic fields from the magnetic loops in the stellar photosphere to the global magnetic field (Henrichs & Sudnik 2013). A reason of the sharp decrease of MFDF for $\mathcal{B} < \mathcal{B}^{\rm th}$ remains unknown.

To investigate the difference between magnetic and non-magnetic stars we plot the $(U-B)_0 - (B-V)_0$ diagram for magnetic and non-magnetic O stars in Fig 2 (left panel, blue triangles and green circles respectively). The distribution of the projected rotation velocities for magnetic and non-magnetic O stars are given in Fig 2 (right panel). Analysing the figure we can conclude that there is only a weak difference between magnetic and non-magnetic O stars. The similar conclusion is valid for magnetic B stars.

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