Astronomical Journal of Azerbaijan, 2020, Vol. 15, No. 2

MAGNETIC FIELDS OF HAEBE STARS: INTERACTION WITH ENVIRONS

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Studies of magnetic fields in Herbig Ae/Be (HAeBe) stars can help us to improve our understanding of how the magnetic fields of these stars are generated and how they influence their environment. Measurements were made for 100 stars and only for around 20 HAeBe stars magnetic fields were detected. We compile the catalog of all measurements of the HAeBe stars magnetic fields. The *rms* mean magnetic field for an ensemble of magnetic HAeBe stars appeasrs to be about of 100 G. This value is ∼3 times smaller than that for main sequence (MS) AB stars. We study how these weak magnetic fields interact with the matter of the circumstellar disk.

textbfKeywords: Stars – Magnetic field – Ae/Be Herbig stars

1. INTRODUCTION

Herbig Ae/Be (HAeBe) stars are intermediate-mass (2-10 $M_\odot$) stars at the pre-MS stage of evolution. We still do not understand the origin of magnetic fields in early-type MS stars.

Recently Kholtygin et al. [5] investigated the statistics and evolution of magnetic HAeBe stars. The mean logarithms of magnetic fields and magnetic fluxes appeared to be significantly (by up to one order of magnitude) lower than the corresponding values for MS stars.

Ferrario et al. [4] supposed that merging of protostars may play an important part in the amplification of the initial, relatively weak magnetic field of the star. It means that magnetic stars can be more massive than non-magnetic ones.

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Presence of the magnetic field can affect the accretion rates for HAeBe stars. All these questions are considered in the present paper.

2. MAGNETIC FIELD DATA AND STATISTICS

Polarimetric observations of stars should be used to determine the longitudinal component B_z of the stellar magnetic field, which is also referred to as *an effective magnetic field*. Up to now the polarimetric observations have been performed for about of 100 HAeBe stars.

The root-mean-squared (rms) magnetic field defined by Borra et al. [2] can be used as the most suitable characteristic of the magnetic field of a star slightly depending on the time when observations were made:

$$\mathcal{B} = \sqrt{\frac{1}{n}\sum_{j=1}^{n}\left(B_z^j\right)^2}, \quad (1)$$

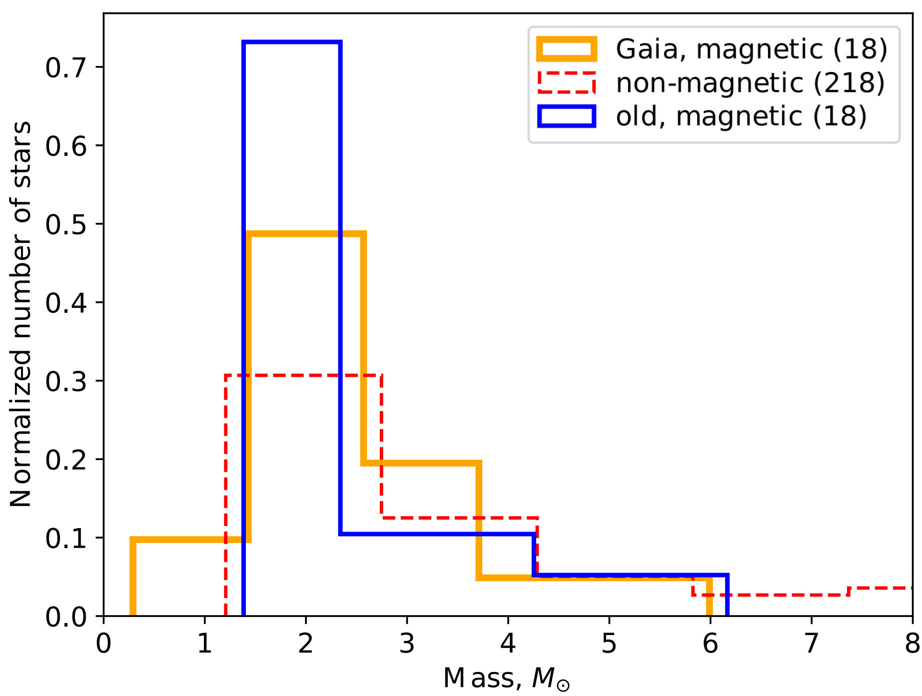

Fig. 1: Distribution of masses of HAeBe stars for magnetic stars with new Gaia DR2 data (thick solid line) and for old mass determinations (thin solid line). Mass distribution for non-magnetic HAeBe stars is shown with dashed line.

Table 1: Mean magnetic fields, magnetic fluxes and the corresponding standard deviations for different groups of HAeBe and MS AB stars (columns 2-5), mean masses and mean accretion rates (columns 6-7) for different groops of stars. Numbers of objects are given in the column 8.

Star	M	Numb.
DD2.000.2725.530.372.53-6.99		20
MD1.910.3125.590.522.47	7.31	9
BS2.100.3825.780.732.80	-	7
MS2.530.5426.420.70 -	-	973

The computed by Kholtygin et al. [5] radii of HAeBe stars R_* may be used to estimate their magnetic fluxes using the following formula:

$$\Phi = 4\pi R_*^2 \mathcal{B}. \tag{2}$$

The mean *rms* magnetic fields and magnetic fluxes for different groups of early-type stars are taken from the Table 2 in the paper by Kholtygin et al. [5] and are given in Table. 1.

In the first row of the table are given data for a group (DD) magnetic HAeBe stars with really defined magnetic fields. The group MD with Marginal Detection of magnetic field includes stars for which at least one magnetic field measurement satisfies a condition $\left|B_z^k\right|/\sigma_k > 2$, where k is the number of the measurement. Binary HAeBe stars with definitely detected magnetic fields are includes in group BS. In the last row of Table. 1 the mean magnetic fields and magnetic fluxes for the main sequence AB stars (group MS) are given. Numbers of objects in group are presented in the last column.

3. MASSES AND ACCRETION RATES

The distribution function of magnetic field can be obtained using the following formula:

$$f(M) \approx \frac{N(M, M+\Delta M)}{N \cdot \Delta M}, \tag{3}$$

where $N(M, M+\Delta M)$ is the number of stars with masses in the interval $[M, M+\Delta M]$ and N is the total number of stars with known mass.

Obtained by us mass distributions for magnetic and non-magnetic HAeBe stars are given in. Fig. 1. Here masses of HAeBe stars are taken from paper by

Vioque et al. [7] ("Gaia, Magnetic") and from papers by Montesinos et al. [6] together with data given by Alecian et al. [1] ("old, magnetic"). For non-magnetic stars their masses are taken from paper [7].

New masses of HAeBe stars estimated by Vioque et al. [7] are used to calculate mean masses for different groups of HAeBe stars. These masses are presented in Table 1. The mean masses of HaEBe stars in binary systems appeared to be approximately 2 times large than for single HaEBe stars.

Recently Fairlamb et al. [3] obtain spectra of 91 HAeBe stars at VLT with X-shooter spectrograph. These observations were used to calculate the accretion rates for these stars. A dependence of calculated accretion rates on the *rms* magnetic field is plotted in Fig. 2. One can suppose that the accretion rates slightly decrease with enhancing the stellar magnetic field.

In Table. 1 we present the mean accretion rates for magnetic HAeBe stars (group DD) and HAeBe stars with marginally detected magnetic fields. The last group has 2 times larger accretion rates than group of HAeBe stars with detected magnetic fields. Basing on these results we can conclude that magnetic field can suppress the accretion.

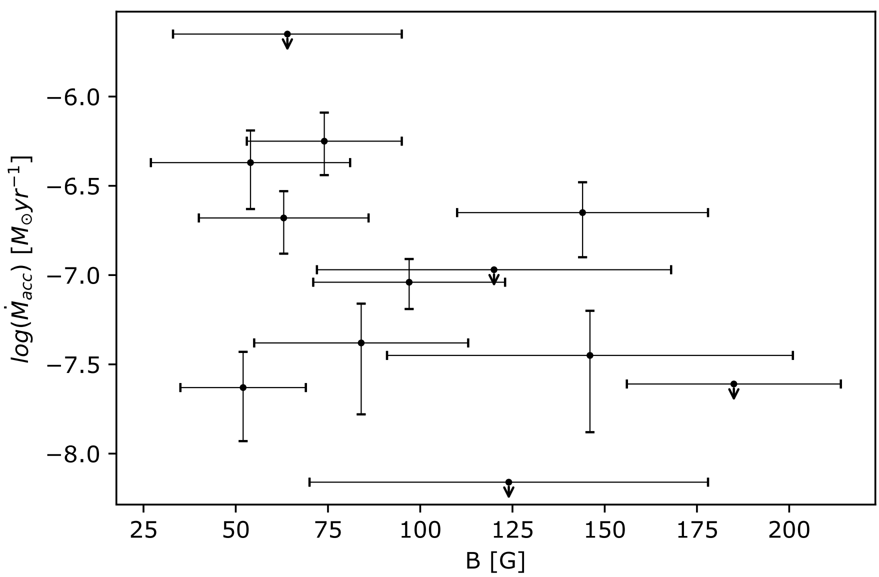

Fig. 2: Accretion rates vs. rms magnetic field for for magnetic HAeBe stars.

4. CONCLUSIONS

Our study led us to the following conclusions:

- Mean magnetic fields and fluxes of intermediate-mass stars HeBe stars with detectable magnetic fields are smaller than the corresponding values for AB stars of the main sequence.
- Mean masses of HeBe stars in the binary systems are 2 times larger than mean masses of single HeBe stars.
- Mean accretion rates of magnetic HeBe stars probably decreases with growing the *rms* magnetic field.

A.K. thanks the Russian Foundation for Basic Research for the support with grant no. 18-02-00554 A.

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