MAGNETIC FIELD VARIABILITY OF STARS

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ABSTRACT. We present in this paper a description for various types of the apparent variations of stellar magnetic fields, which we actually recognise.

Key words: Stars: magnetic field; stars: fundamental parameter

1. Introduction

Recently we investigated magnetic behavior of 139 stars, including 134 Ap stars and 5 solar-type stars (Bychkov et al. 2005a). Results of this research allowd us to recognize 7 classes of stars which exhibit specific types of the apparent magnetic field variations.

Ap stars usually exhibit strong global magnetic fields. Occurence of global magnetic field of a given strength in subclasses of Ap stars of various chemical peculiarities was studied e.g. by Bychkov et al. (2003).

In the following sections we discuss variability of the so-called effective magnetic field B_e, which is the most easily observable quantity derived from the real magnetic field of a star. The actual value of B_e is usually determined from the Zeeman splitting of hydrogen or metal spectral lines.

2. Types of the stellar magnetic variability

Type I. Simple harmonic. Variability of the effective magnetic field B_e in most of Ap-stars investigated up to now ($\approx 87\%$) exhibits form of a simple sine wave. Half-amplitudes of the sine wave typically are in the range from few tens to few thousands G, see Fig. 1 (Bychkov et al. 2005a). Period of the above magnetic variations equals to the rotational period of a given star. Such a variability is fully described in frame of the Stibbs-Preston oblique rotator model.

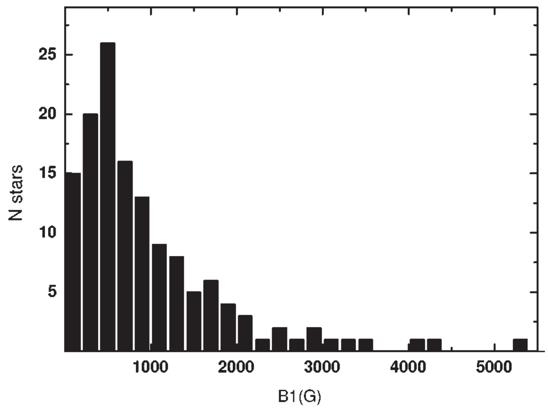

Figure 1: Number distribution of the half-amplitude B_e variability.

Type II. Double wave variations. Behavior of the effective magnetic field $B_e(t)$ as a function of time t is not as simple as the sine wave. In such a case the shape of B_e is best described by a sine wave with overlying second harmonic term, the latter with the amplitude typically $10 - 20\%$ of the main harmonic.

The number of stars with double wave $B_e(t)$ is $\approx 13\%$ of the total number of known stars which have measurable global magnetic fields. Well known magnetic stars which exhibit double wave variations of B_e is HD 32633, named Renson's star (Renson 1984), see Fig. 2.

Such the form of the curve $B_e(t)$ is generated by a rotating quadrupole.

Type III. Complex variations. There exist stars where $B_e(t)$ cannot be given by simple formulae. Example of such a star is HD 37776 (Thompson & Landstreet 1985), see Fig. 3. The number of stars with complex $B_e(t)$ is less than 1% of the total number.

Type IV. Long period variations. Research on magnetic fields of stars has started over 50 years ago. During that time period researchers accumulated long time series of magnetic measurements for a number of stars. Such series allow one to study of the long-period (secular) variability of the global magnetic field. The

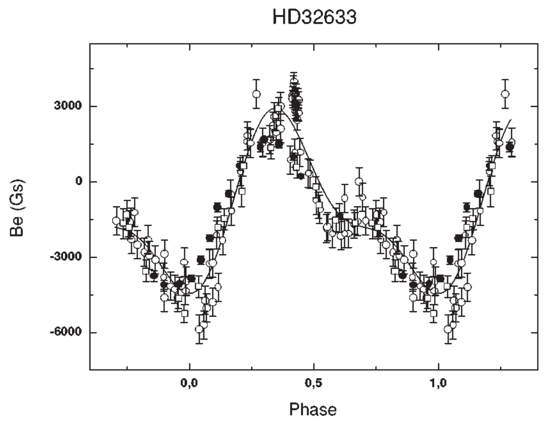

Figure 2: Magnetic phase curve B_e for HD 32633 (Renson 1984).

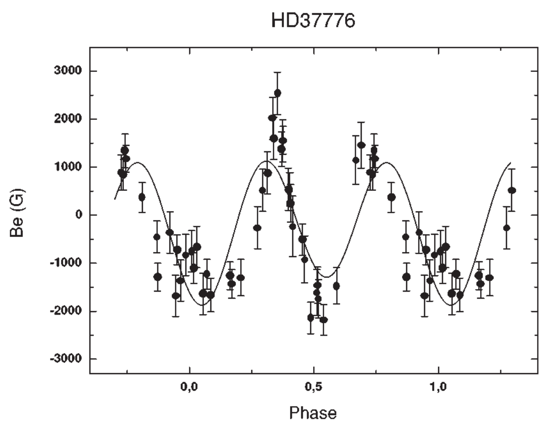

Figure 3: Magnetic phase curve B_e for HD 37776 (Landstreet & Thompson 1985).

occurence of such a variability in stars is low, and do not exceed 3 %.

The outstanding example is the Ap star HD 201601 (γ Equ) (Bychkov et al. 2006).

Type V. Irregular magnetic variations. The only known star with irregular magnetic variations is 52 Her. This star usually displays typical sine wave $B_e(t)$ with the average intensity +500 G. However, in the time interval JD 2442400 – 2444200 the average intensity of the effective magnetic field decreased to −3500 G, and later the value of $\langle B_e \rangle$ in slowly increased to +500 G.

Actually there is no convincing explanation for such a behavior of 52 Her.

Type VI. Rapid variations. There exist a group of rapidly oscillating Ap-stars, with display also rapid variations of the global effective magnetic field B_e (Leone & Kurtz 2003; Bychkov et al. 2005b). Rapid variations proceed with periods 3 – 12 min. and are caused by non-radial pulsations of the star and its magnetic field.

Type VII. Late-type stars with global magnetic fields. The use of new technologies for the measurements of stellar magnetic fields has lead to the discovery of weak magnetic fields in late-type stars. Strong local magnetic fields in surface layers of late-type stars were known from a long time. However, weak global fields recently were found in a number of stars, see Plachinda & Tarasova (2000), Neiner et al. (2003). The amplitude of periodic variations of B_e in late-type stars does not exceed few tens of G.

3. Summary

In this paper we presented general description of stellar magnetic variability of all types which were recognised up to date. The principal aim of such a description is the search of an answer for the principal question: **what is the origin and evolution of global magnetic fields in stars ?**

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