Magnetic field model of the star HD 126515

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Using the technique described in the paper by Gerth et al. (1997), we kept modeling of the CP stars. The magnetic field is specified by inserting magnetic monopoles inside the star. The field component directed to the observer is integrated over the visible hemisphere with allowance made for limb darkening, that is, we calculate that value of B_e which is measured with the magnetometer by the Zeeman method. The position of the monopoles is defined by their distance r from the centre of the star and by coordinates in latitude δ and longitude λ. By computing B_e for a number of phases P, we obtain model curves B_e (*P*) and B (*P*) (B_s is the average surface field), which are compared with the observed ones. Selecting the parameters by the iteration method, one can bring into coincidence the computed and observed curves.

The measuring precision of the magnetic field B_e at present is such that it allows the angle χ to be estimated with an intrinsic accuracy *of ff* = ±1°, and B_p with an accuracy σ = ± 2 B 5%. Given the curves $B_e(P)$ and $B_s(P)$, in most cases one can measure both angles *i* and χ.

The star HD 126515 (SrCrEu) belongs to stars having anharmonic curves of magnetic field Variation (Preston, 1970; Mathys, 1995) (see Fig. la); that is why it is of interest to construct a magnetic field model for it. Unfortunately, the effective magnetic field in all these papers is measured from metal lines, therefore their inhomogeneous distribution over the surface will inevitably affect the $B_e(P)$ curve shape. This means that the model parameters may be distorted. Besides, the insufficient uniformity of the measurement distribution along the period phases will also have an effect on the accuracy of the results obtained. The star rotates with a very large period, P = 130 days, therefore the angle *i* cannot be estimated from $v \sin i$. However, data of average surface magnetic field measurements (Preston, 1970; Mathys, 1995) are available, which are shown in Fig. 1. The B_e data of Mathys (1995) are systematically larger than those of Preston; that is why they have been reduced to the latter.

a) Displaced dipole model

The central dipole model describes inadequately the observed relationships. For this reason a displaced dipole model has been computed. It has appeared that the best fit to the observed relationships is provided by a model in which the dipole is displaced along the axis towards the negative monopole by a value of r = 0.49 of the star's radius and also in the direction normally to the dipole axis, so that the plane in which all the monopoles are located be at a latitude of 30°, which corresponds to a shift in fraction of the radius r = 0.5. The coordinates of the monopoles are listed in Table 1.

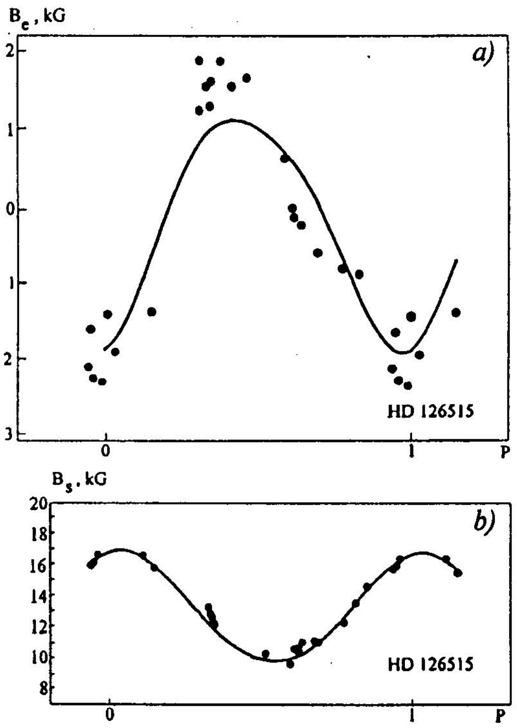

Figure 1: *Observed and modeled (solid line) variations of B_e and B_e with phase of the rotation period for HD 126515.*

The corresponding B_e and B_s curve are the solid lines in Fig. 1. It can be seen that there is an insignificant deviation at phases *P* > 0.5 on the $B_e(P)$ curve, while on the curve $B_s(P)$ the model curve has a somewhat larger amplitude, although, on average, the two model curves are a good fit to the observations.

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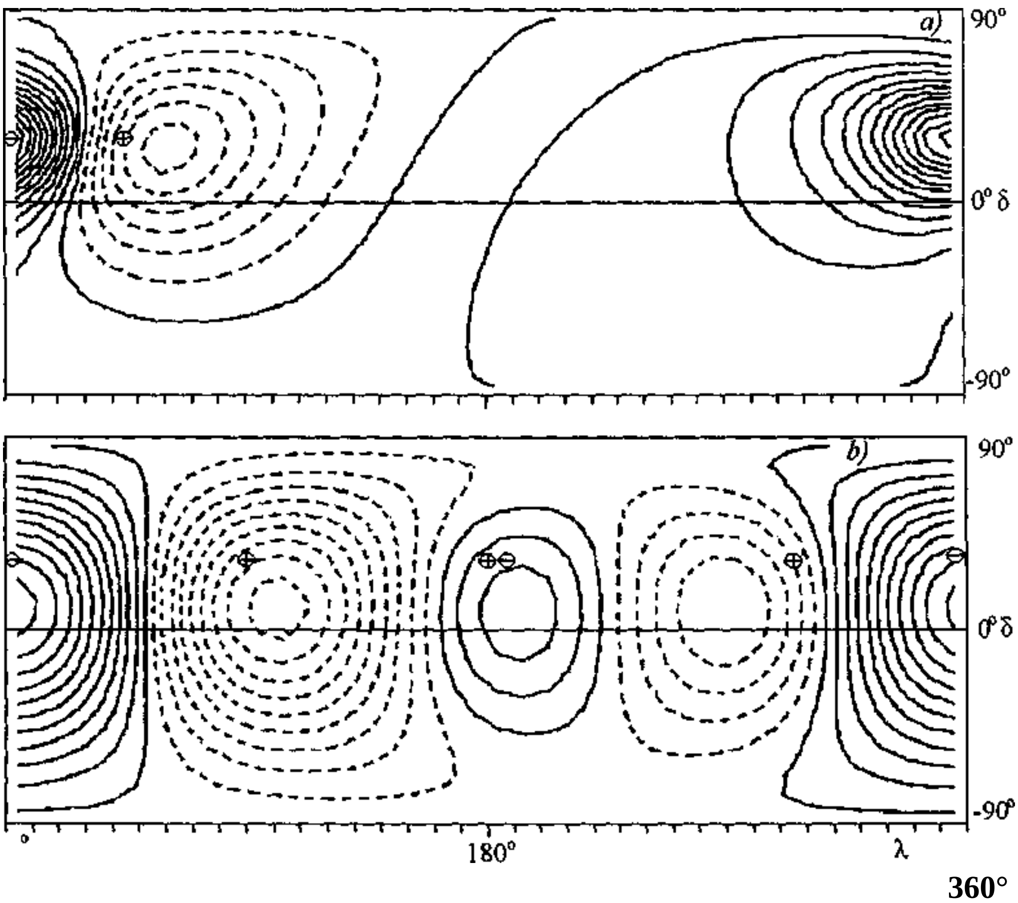

Figure 2: *Magnetic field distribution over the surface of HD 126515 obtained from the displaced dipole model (a) and dipole-quadrupole model (b).*

Table 1: *Displaced dipole magnetic field parameters*

Strength B_p kG	r	Longitude degr.	Latitude degr.
B60	0.55	0	30
20	B 0.37	45	30

The model curves also follow well the phase shift of the curves $B_e(P)$ and $B_s(P)$ which is not seen in Preston's (1970) model. The same results have been obtained by Stift, Goossens (1991). The field strength distribution over the surface is shown in Fig. 2a. The star inclination angle i = 16° (Preston's result 17°, Stift and Goossens' 25°).

Table l illustrate the large field strengths at the poles. The Separation of the dipoles is about 0.18 star's radius, and the dipole is displaced towards the monopole by about 0.46 star's radius. Thus the asymmetry of the magnetic field of HD 126515 is very strong. In Preston's (1970) model, the dipole is displaced by r = 0.36 in the same direction.

Table 2: *Dipole-quadrupole magnetic field parameters*

Field model	r	Longitude degr.	Latitude degr.
Dipole	0.1	0	32
	0.1	180	32
Quadrupole	0.1	0	32
	0.1	90	32
	0.1	180	32
	0.1	295	32

b) Dipole-quadrupole model

An attempt to construct a dipole-quadrupole model has failed satisfactory results. The best fit of the model and observed $B_e(P)$ and $B_S(P)$ curves turned out to occur with the following parameters.

The field strength at the maximum points is -35 kG and +29 kG. In Fig. 2b is presented the map of the magnetic field strength distribution over the surface which has been obtained from the dipole-quadrupole model. It is seen that two principal magnetic regions co-incide, however two weaker regions, which are absent in the former case, have appeared.

No perfect fit of the model and observed curves has been achieved probably because of the influence of the inhomogeneous distribution of chemical elements and more complex, than described by the model, magnetic field distribution over the surface. The star inclination angle to the line of sight is i = 19°, the dipole axis is inclined to the rotation axis at an angle β = 70° (85° by Preston). The temperature of the star is T_e = 9650 K (Glagolevskij, 1994), the parameter β = 2.918. Via the calibration of Crowford (1979) and bolometric corrections from Straizis, Kuriliene (1981) we find the stellar bolometric magnitude M_b = 1.38. Using M_v = 1.1 (Gomez et al., 1998), we find M_b = 0.9. These two values correspond to R/Hz = 1.0 and 1.2, wherefrom the mean value of this parameter is 1.1. Thus, this is a very young star located near the zero age line in the Hertzsprung-Russell diagram.

Having a look at the map of the field strength distribution over the surface of the star in Fig. 2, one can see that there are two closely spaced strong-field regions. The dashed line shows the border between the positive and negative magnetic field (zero field). The small circles indicate the points at which the monopoles are situated. The star is thus seen to have an extremely asymmetric field distribution of high negative intensity. This fact is consistent with the assumptions that the recently developed field has a complicated structure, which simplifies as the result of ohmic dissipation. So far, we have not noticed such complex magnetic field configurations in old-age stars.

It is hardly to be supposed that with compression of rnagnetised clouds at the initial stages of star formation heavily asymmetric magnetic field structures might have been produced. It is also unlikely that the generation of a strongly asymmetric magnetic field at the convective phase at early stages of evolution is due to the symmetry of a star. It is possible that the magnetic field emerges asymmetrically when the star arrives on the main sequence. This may occur under the action of inhomogeneous, asymmetric processes in the star, for instance, asymmetric accretion of huge masses.

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