The magnetic model of 53 Cam

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The results of the first investigations of the magnetic field structure of peculiar stars with our new method were published by Gerth et al. (1997, 1998). In this paper we study the structure of the magnetic field of the well-known star 53 Cam, for which the curves of variability of the effective (B_e) and mean surface (B_s) magnetic fields with phase of rotation (P) are known. This circumstance allows a more accurate determination of all magnetic field parameters than it would be possible by using only one of the curves. For example, it would be necessary to estimate the inclination angle (*i*) from *v* sin *i*, which is often not accurate enough.

The procedure of our model calculations consists in choosing the magnetic moment Q for magnetic monopoles, their coordinates on the star, and the angle *i*. The average vector of the magnetic field B_e (directed to the observer), and the mean value of the surface magnetic field B_s are calculated with these parameters. By determining B_e and B_s at different rotational phases we obtain the calculated curves B_e(P) and B_s(P), which we compare with the observed ones. The adaptation of the parameters allows one to achieve a maximum fit of the computed and measured curves by the least squares method optimization.

The B_e observational data of Borra and Landstreet (1977) obtained with a hydrogen line polarimeter have been used. The data for B, obtained only from metallic lines have been taken from Huchra (1972). The data for B_8 are affected by the inhomogeneous distribution of chemical elements.

Three types of magnetic models have been calculated.

- The model of decentered dipole (DecD).
- The dipole + quadrupole model (D + Q).
- The dipole + quadrupole + sextupole model (D + Q + S).

The results are shown in Table l among the data obtained by other authors. The comparison of the model data with the measured data is shown in Fig. l as isolines. The isolines of the magnetic field strength distribution over the surface of the star obtained by models l, 2 and 3 are shown in Fig. 2. The approximation to the measured data have been performed by the Iteration method.

Let us now discuss Fig. l, Fig. 2 and Table 1. It is

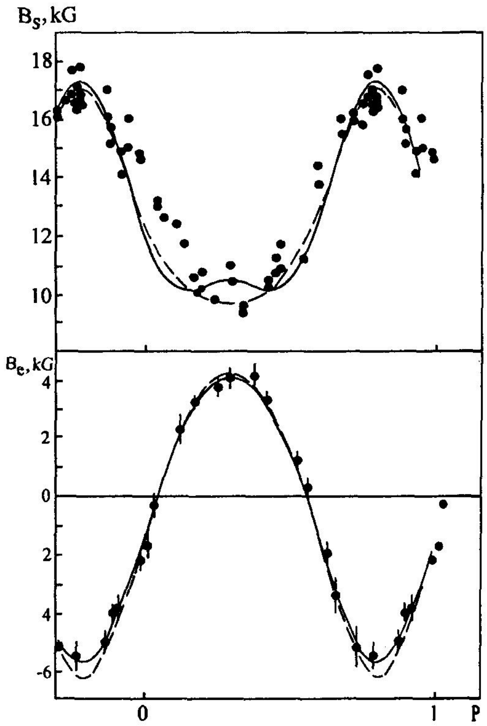

Figure 1: *The observed (circles) and model curves of variations of the surface (B_3) and effective (B_e) magnetic fields of 53 Cam. The solid line is the model for (DecD), and the dashed line is the model for (D + Q) and (D + Q + S).*

seen that the relation B_e(P) is well represent-ed by all three methods, however, the dependence B_S(P) is modeled worse. The amplitudes of the measured and calculated Bs coincide, but the observ-ed curve has a noticeable narrower shape. This discrepancy arise in consequence of the inhomo-geneous distribution of chemical elements over the surface. The chemical elements, from which the mag-netic field was determined, are distributed along the magnetic equator (see later). The magnetic maps in Fig. 2 (DecD) show the existence of two main regions with a positive and

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Table 1:

Authors	Model	i	β	Bp(+)	Bp(−)	a
This work	DecD	58°	85°	12600	29600	-0.14
	D + Q	64	87	12600	26600	0
	D+Q+S	62	87	11900	28700	0
Borra, Landstreet, 1977	DecD	65	80	-	28000	-0.14
Huchra, 1972	DecD	50	80	-	28400	-0.145
Landstreet, 1988	DecD	72	75	10290	15730	-0.10
Landstreet, 1988	D+Q+O	64	82	(-16300, -7300, 4900)		0

Comments:

DecD - decentered dipole;

D+Q - dipole+quadrupole model

D+Q+S -dipole+quadrupole+sextupole model

D+Q+O - dipole+quadrupole+octupole model

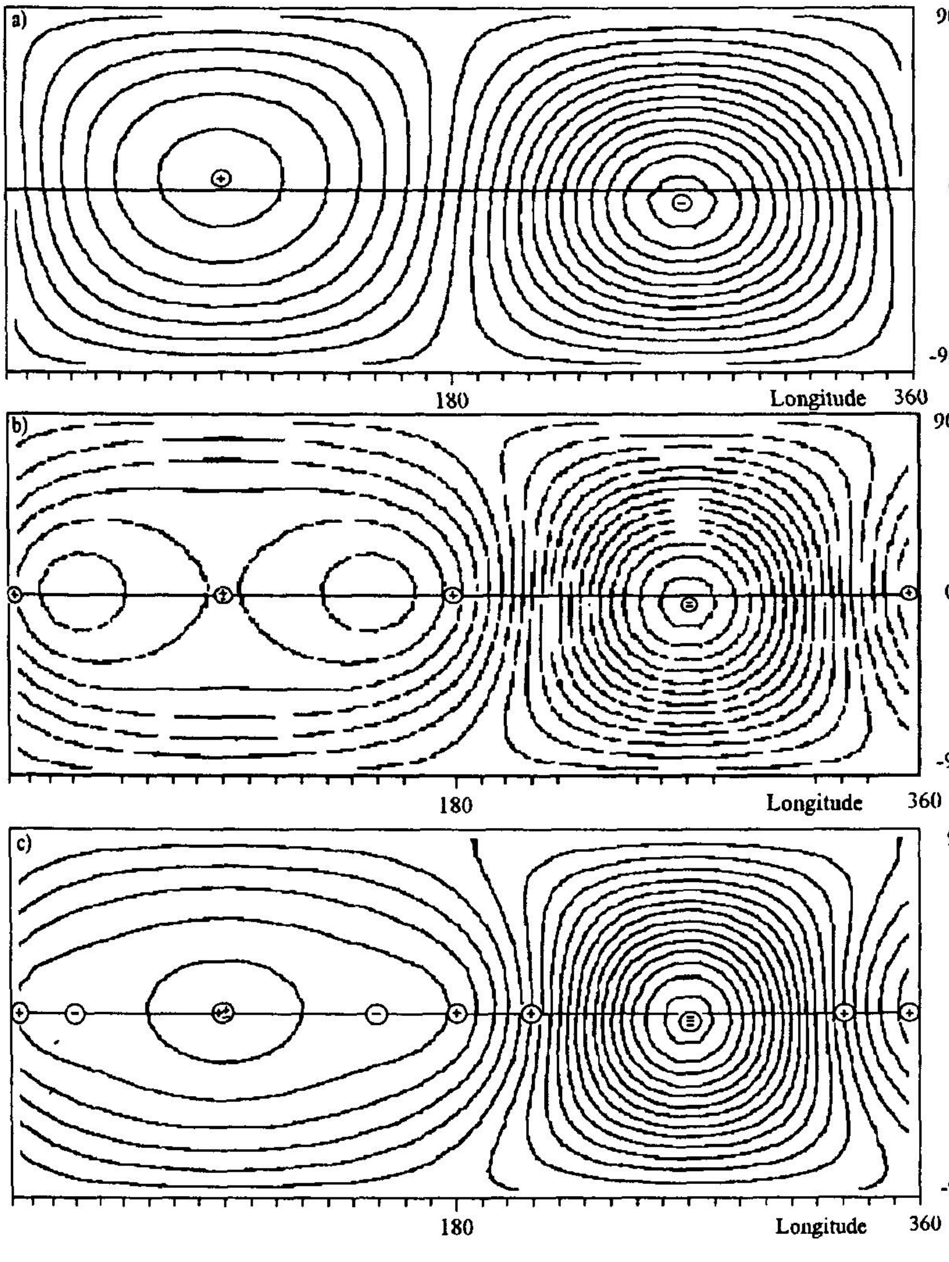

Figure 2: Isolines of the magnetic field strength distribution over the surface of 53 Cam computed from three models: a) - (DecD), b) - (D + Q), c) - (D + Q + S).

negative polarity, the size of the forrner being essentially larger. It should be noted that in the positive hemisphere the dipole-quadrupole model results in two weak additional maxima, which are absent in other models. This gives evidence for imperfection of the dipole-quadrupole representation of the magnetic field structure, despite the fact that the parameters prove to be within the errors (see Table 1). The introduction of a sextupole component of the magnetic field removes the two discussed maxima. It is obvious that the addition of the sextupole, octupole, etc results in the first version. It is interesting that the introduction of the sextupole component practically does not influence the dependence $B_e(P)$ and $B_S(P)$, but has a notable effect on the magnetic field distribution over the surface (see Fig. 2c). The introduction of the octupole instead of the sextupole proves to be less effective.

In Table l by *i* and *ß* are denoted the inclination of the Star and the angle between the dipole axis and the axis of rotation, Bp(+) and Bp(B) are the inagnitudes of the magnetic field at the positive and negative poles. Parameter a is the value of the decentration of the dipole from the star's center in units of the radius.

From Table l we can see that all the values *of* and *ß* are close enough. The average of *i* = 62° ± 3°, *ß* =82° ± 2°. Other average values: Bp(+) = 11.8k G ± 2kG, Bp(B) = B26.2kG ± 3kG, a = 0.134 ± 0.011. For the central models we have a = 0.

In our calculations the limb darkening coefficient *k* = 0.575 is taken from (Landstreet, 1988).

The modeling has shown that the distinctive shape of the dependence $B_e(P)$ obtained by Babcock (1960) and presented in Fig. 3 can be explained by the fact that the characteristic chemical elements, which are used for the magnetic field B_e determination, are distributed along the belt near the magnetic equator. This belt is displaced a little in the direction of the negative magnetic pole. Under this assumption the model leads to the relation $B_e(P)$ shown in Fig. 3 by the solid line.

It has finally been concluded that a displaced dipole is the most probable magnetic field structure for 53 Cam.

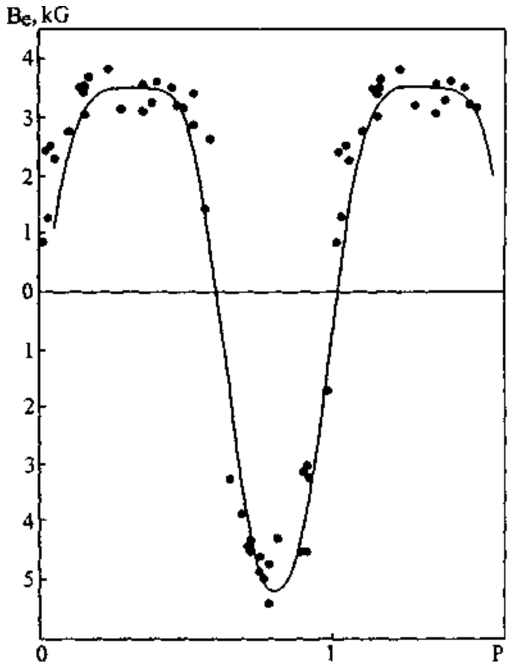

Figure 3: *The observed (circles) and modeled effective magnetic field* variations of 53 Cam, *assuming that the characteristic chemical elements are concentrated along the displaced dipole equator.*

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