The magnetic model of HD 37776

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Abstract.[1]) A magnetic model of the Be star HD 37776 is constructed using observational data from THOMPSON & LANDSTREET and ROMANYUK and applying the method of the Magnetic Charge Distribution (MCD).

Modeling of the magnetic field of the CP star HD 37776 has been made by the method described in the papers given by GERTH et al. (1997), GERTH et al. (1998), and GERTH & GLAGOLEVSKIJ (2000).

HD 37776 is a B5 star with a rotational period of 1.5385 d. The measurements of the effective magnetic field B_e carried out by THOMPSON & LANDSTREET (1985) are shown in Fig. 1.

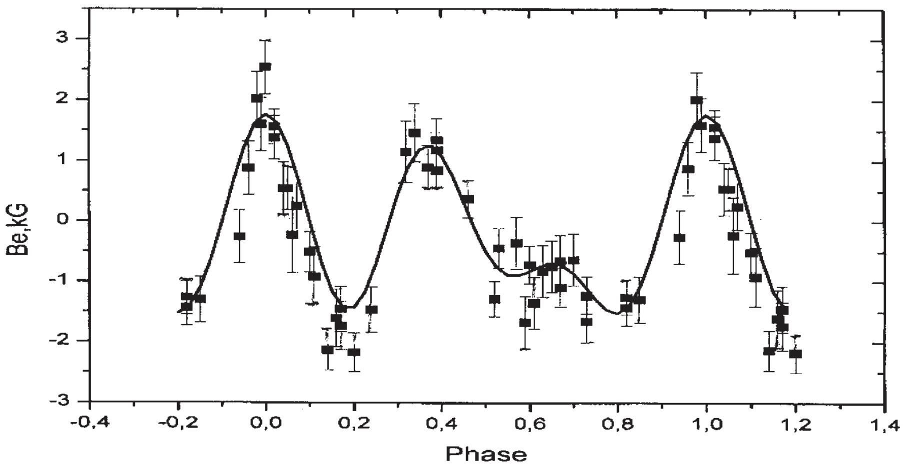

Figure 1. Phase diagram with data from THOMPSON and LANDSTREET

These measurements were made by the hydrogen lines, therefore, the values are probably not distorted by the influence of the inhomogeneous distribution of chemical elements over the surface.

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Besides of this, there are also some measurements of the average surface field B_s made by Romanyuk et al. (1999), see Fig. 2.

The simultaneous use of the B_e and B_s data allows quite confidently to determine the angle of inclination i to the line of sight. Deviating from the assumption we made in a previous paper (Gerth et al., 1997), we calculated now a model by introducing the combination dipole + quadrupole + etc. In this case we insert inside the star the *magnetic charges* of the monopoles and their position, which results in the coincidence of the calculated dependencies $B_e(P)$ and $B_s(P)$ with the observed ones. The magnetic monopoles combine to dipoles and multipoles. They are used for the construction of the surface field by a computer program. The unit of the *magnetic charge* is Gauss·cm^2.

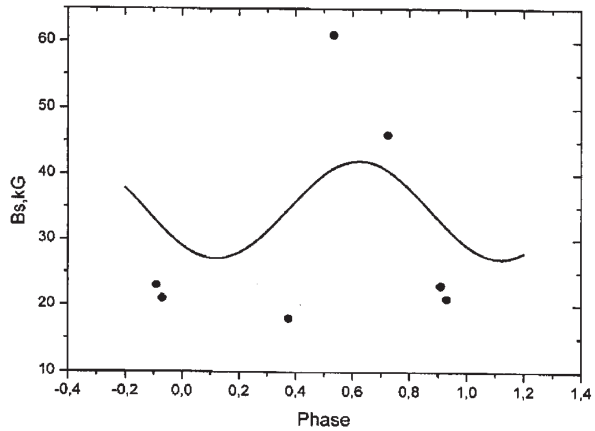

Figure 2. Phase diagram with measuring data from Romanyuk

Manipulating the coordinates and the distances of the monopoles with constant magnetic charges from the star center, the dependencies $B_e(P)$ and $B_s(P)$ were calculated, as shown in Fig.1 and 2 by the curves. This is performed iteratively method. At the first step we can see that in the star prevails the configuration of six magnetic field sources, whose fields combine to a dipole field with complicated structure. In Fig.3 the phase curve for this case is shown, where all the magnetic monopoles are distributed on the equatorial plane. One can see that the curve $B_e(P)$, calculated from the extreme values, coincides with the observed curve, but the amplitudes are distorted.

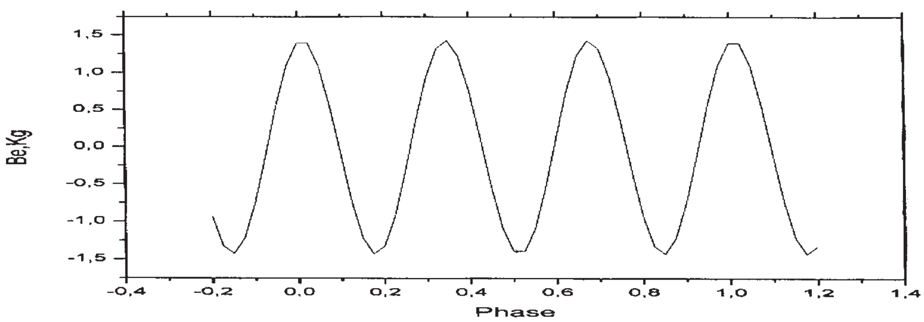

Figure 3. First approximation starting from six magnetic monopoles

Unfortunately, the lack of quantity concerning the measurements of B_s is violent. This is why we attempted at first to obtain the average value of the longitudinal magnetic field. The amplitude of the model curve $B_s(P)$ is smaller than the observed one, but the form is rather similar. There is urgent demand for additional observation. The model curves $B_e(P)$ do coincide excellently.

In Fig. 4 the distribution of the magnetic field strength over the stars surface is shown. The position of the magnetic monopoles is marked by circles with signs + or -. Isolines are drawn in such manner that the maximal strength of the magnetic field is divided by 24 levels. The coordinates and the distances of the monopoles from the star center are given in Table 1. Evidently, the locations of the monopoles and those of the poles do not coincide. The locations of the poles, resulting from superposition of the fields, are: $N(227^o, 67^o), S(210^o, -64^o)$.

The positive monopoles are located in one hemisphere and the negative ones in the other. They are distributed over the latitude irregularly, but over the longitude they are distant practically by 60^o one from the other. It is possible to imagine also, that the magnetic field of HD 37776 is determined by three dipoles oriented to the rotation axes and to the equatorial plane by different angles. Note, that the average distance of the magnetic monopoles from the center of the star is $a = 0.18$ of the star radius. This means that the magnetic field will be described by a field of the "pivot" but not by the "point dipole". The calculated curves Be(P) and $B_s(P)$ are very sensitive to the parameter a. This is why the step of variation for the parameter a was chosen by 0.001. The decreasing of a produces a "wash-out" of the dependence and an increasing of a. Our modeling confirmed the declination the angle $i = 90^o$ derived by Bohlender (1998), which is close to our determination of $i = 82^o$ by Gerth et al. (1998). Changing of the angle i even by 1^o results in a variation of $B(P)$ by values comparable with the scatter errors. The charge is given in relative units.

Table 1.

No	Charge	a	Long.	Lat.
1	46	0.180	0	0
2	-46	0.182	58	0
3	46	0.167	120	12
4	-46	0.176	181	-22
5	46	0.176	240	28
6	-46	0.176	300	-15

We consider this result of modeling as a variant. The model must be specified after addition of further measurements of B_s. The next model has to take into account the distribution of the chemical elements by the spectral lines, which was determined as the mean surface magnetic field.

We see that the structure of the magnetic field of HD 37776 is rather complicated. This complication probably is connected with the surface processes in the stage of evolution "before the main sequence". The star HD 37776 is young and the magnetic field is in the stage of formation.

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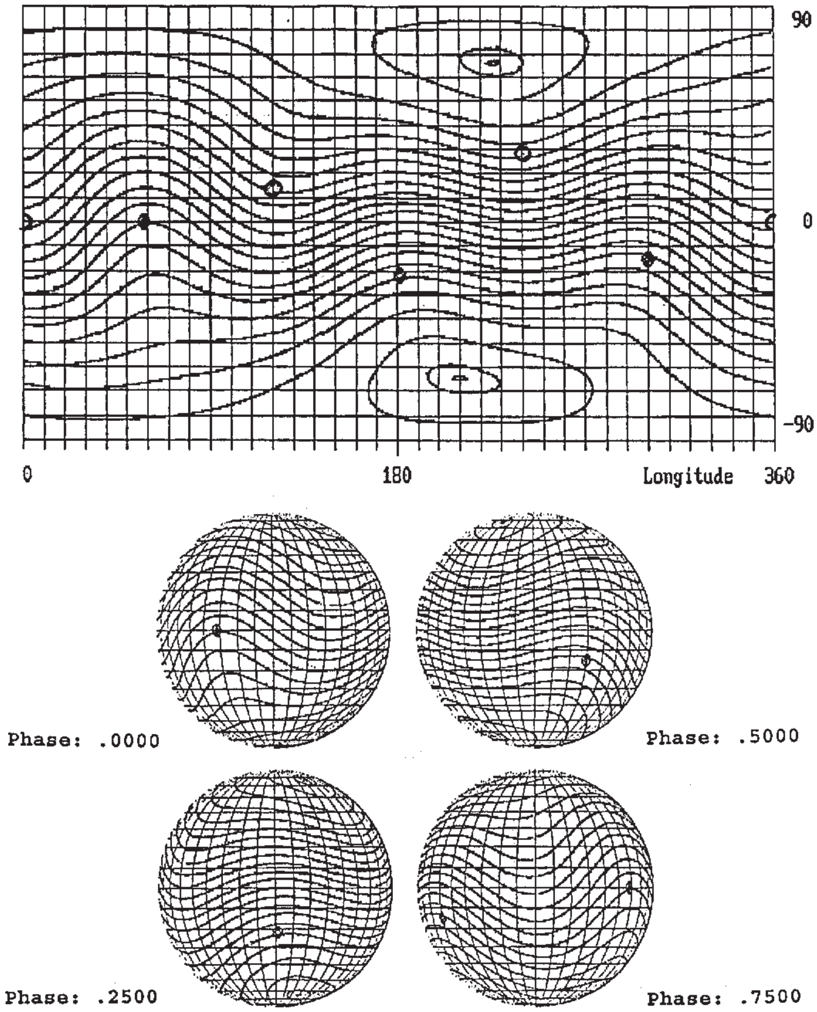

Figure 4. Pseudo-Mercator map and globes with the phases 0, 0.25, 0.5, 0.75 of the magnetic field. The magnetic maps are calculated and graphically represented by a computer program using the MCD-method (Magnetic Charge Distribution) after Gerth and Glagolevskij (2001).