THE MAGNETIC FIELD OF EPSIL0N UMa

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ABSTRACT. In the spectrum of ε UMa an effective magnetic field strength up to 1000 Gs was detected in the lines of the inhomogeneously distributed elements Ft I, II, Cr I, II, Ti II. Model calculations show, that the difference of these B_e values with those determined earlier by measurements on hydrogen lines cannot be completely explained by the inhomogeneous metal distribution.

1. INTRODUCTION.

ε UMa is one of the brightest CP stars (m=1.^{m}68) and therefore studied in many respects. The spectrum of this star exhibits a great similarity with that of a CP2 star, but in contrast to the other members of this group, the effective magnetic field strength, B_e, of £ UMa - measured in the wings of hydrogen lines by a photoelectric technique - is very stall: B_e < 110 Gs (Borra, Landstreet, 1980), -300 +800 Gs (G1agoltvskij et al., 1981). Khokhlova et al. (1982) found, that the elements Fe and Cr are not homogeneously distributed over the star surface, tore precisely these elements are concentrated in two opposite regions near the rotation equator.

2. MEASUREMENTS

We tried to measure B_e by Babcock's photographic technique, using the lines of Fe I, II, Cr I,II, Ti II. 20 Zeeman spectrograms with a reciprocal linear dispersion of 4 A/ee were taken with the 2-e universal telescope at Tautenburg/Jena in springtime of the years 1984 and 1986. All spectrograms were measured with the modified version of the Abbe comparator of the Institute of Astrophysics at Potsdam and reduced with a program written by Berth. For plates taken at the mean phases 0.12, 0.56, 0.90 the wings of the whole line profiles were used to derive B^e .But for seven spectrograms taken in the phases between 0.66 and 0.73 and two in the phases 0.27 , 0.28 - these are the rotational phases, when the regions of enhanced element concentration appear at opposite stellar limbs, indicated by line splitting in our spectrograms - we tried to determine the effective magnetic field separately for longwave component and shortwave one. Generally, the following procedure was applied to increase the accuracy in B_e determination: for spectrograms of adjacent phases the average of the measured line shifts $\overline{\Delta\lambda}$ of a spectral line was used to derive a dependence $\overline{\Delta\lambda}/\lambda^2$ on the Lande factor z. From the inclination of the straight line which represents the relation $\overline{\Delta\lambda}/\lambda^2 = c B_e z$, the following values of B_e are derived (Tab.1)

The weight used corresponds to the deviation of the individual values from a normal distribution. In any case the effective magnetic field of ε UMa, which we derived in this way, is much larger than that found earlier by photoelectric investigation of the hydrogen lines for magnetic broadening.

MODEL CALCULATIONS

To solve the question whether the difference in the observed B_e - a small one when derived from the hydrogen lines and a large B_e up to 1000 Gs when derived from the lines of Fe, Cr and other metals - may be explained by the difference in the local distribution of metals (Fe, Cr) and of hydrogen at the stellar surface we made some model calculations using the observed distribution of Fe and Cr, respectively H and a suitable magnetic field structure. The model for magnetic field structure was suggested by theoretical investigations. In the case of dynamo excitation symmetry or antisymmetry with respect to the rotational equatorial plane is to prefer (Krause, 1971). We have chosen the most simple equatorial symmetric model, by which the observed variation and the difference between north and south polarity can be represented: the superposition of a dipole with its axis in the equatorial plane and an axial quadrupole symmetric to the rotational axis. In such a model the equipotential lines resemble at the stronger pole ellipses, which are very similar to those of constant line strength of Fe and Cr after Khokhlova et al.. The physical process which produces the inhomogeneities is not satisfactory known but an assumption of the same symmetries in magnetic structure and inhomogeneities probably may be made.

Table 1

Phase	$B_e \pm \sigma$ (Gs) unweighted	$B_e \pm \sigma$ (Gs) weighted
0.12	−826 ± 150	−863 ± 89
0.56	+733 ± 355	+684 ± 237
0.90	−785 ± 192	−879 ± 176
0.70	+454 ± 286	+708 ± 205 (longwave comp.)
0.70	−934 ± 175	−1100 ± 136 (shortwave comp.)

In our calculations of B_e the magnetic moments of dipole to quadrupole were used as parameters. For the inhomogeneities in the metallic element concentration, two distributions were used. In the first case the local equivalent width of Khochlova et al. were used directly and in the second case a modification was made, assuming equatorial symmetric local equivalent width but leaving the observed integral equivalent width unchanged. The best fit of the measurements on metallic lines with the calculations gives a model with equal moments of dipole and quadrupole, and a symmetrical metal distribution and an inclination of the line of sight to the axis of rotation by i = 60°. (Such an inclination is obtained by the discussion of v sin i, the period and the radius of ε UMa, too). The calculated values of B_e in the case of homogeneously distributed hydrogen vary between -600 and 550 6s in this model.

Concluding we summarize that the observed large difference in Be between measurements on hydrogen lines and metallic lines can be reduced when the inhomogeneous distribution of the metals is taken into account, but not fully explained by this effect.

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