1973ApJ...186..959B

The Astrophysical Journal, **186**:959–960, 1973 December 15
© 1973. The American Astronomical Society. All rights reserved. Printed in U.S.A.

53 CAMELOPARDALIS AND THE TRANSVERSE ZEEMAN EFFECT IN Hβ

Ermanno F. Borra
Hale Observatories, Carnegie Institution of Washington, California Institute of Technology
Received 1973 March 26; revised 1973 July 9

ABSTRACT

Models for the magnetic star 53 Camelopardalis show that theoretical values for the linear polarization in Hβ, using Unno's LTE theory of radiation transfer in the presence of a magnetic field, are two orders of magnitude smaller than the observed values reported by Kemp and Wolstencroft.

Subject headings: magnetic stars — stars, individual — Zeeman effect

Kemp and Wolstencroft (1973) have found intrinsic linear polarization in Hβ and in a broad band in the continuum of the magnetic stars 53 Cam and HD 215441. A possible explanation of the linear polarization found in Hβ is that it is caused by the transverse Zeeman effect.

I computed the linear polarization in Hβ, for 53 Cam, using the computer program described by Borra (1972, 1973). The Stokes parameters are computed using the analytic solutions to the equations of transfer in the presence of a magnetic field for the Milne-Eddington LTE approximation (Unno 1956). The Stokes parameters are integrated numerically over the visible disk of a star having the magnetic field geometry given by Huchra (1972). The spectral line is assumed to have a simple triplet splitting. The wavelength dependence of the absorption coefficients of the π and σ components are assumed to be of the form

$$K(\Delta\lambda) = C_n E_0^{3/2}[1 + R(N, T)(\Delta\lambda)^{1/2}]/\Delta\lambda^{5/2}$$

(see Aller 1963 for the meaning of the various symbols).

The models predict a linear polarization two orders of magnitude lower than observed. At the phase of positive extremum for the longitudinal field (close to phase 0.23 of Kemp and Wolstencroft), the model predicts a linear polarization ~ 0.001 percent in the core of Hβ for a bandpass ~ 15 Å. This is to be compared with the observed 0.14 percent. The models predict a linear polarization of the same order throughout the cycle, reaching a maximum of 0.003 percent at crossover.

It is to be stressed that on the basis of these calculations alone we cannot definitely rule out the transverse Zeeman effect. The LTE theory used is a simple one, and it is conceivable to the inclusion of NLTE and magneto-optical effects will decrease this rather large discrepancy. Changing other parameters of the models (such as the geometry of the magnetic field) can also increase the linear polarization. However, the models do predict a circular polarization ~ 0.2 percent (with a 15-Å bandpass) in the wings of Hβ, in agreement with a longitudinal field of 3700 gauss and the observations. Also, the geometry of the magnetic field would have to be changed drastically (with the Unno theory) to match the observations. A large transverse field, incompatible with the surface field values measured by Huchra (1972), would be required.

Any mechanism invoking transverse fields in 53 Cam to account for the linear polarization both in Hβ and the continuum will have the difficult task of explaining why the linear polarization is at maximum (at least for the portion of the cycle

© American Astronomical Society • Provided by the NASA Astrophysics Data System

1973ApJ...186..959B

presently covered) when the longitudinal field is at maximum and the surface field at minimum, thus presumably when the transverse field is at minimum. This argument is valid if both the instrumental and interstellar polarization are small compared with the signals measured—a condition which appears to be met in this case (Kemp and Wolstencroft 1973; and Kemp, private communication).

I have not attempted a model for HD 215441, as none is available in the literature. However, the linear polarization in Hβ appears to be incompatible with the surface fields measured by Preston (1969) and with the Unno LTE theory.

I wish to thank the Carnegie Institution of Washington for the award of a Carnegie postdoctoral fellowship and Dr. R. F. Howard for the use of the computing facilities of the solar division.

REFERENCES

Aller, L. H. 1963, *The Atmosphere of the Sun and Stars* (New York: Ronald Press).
Borra, E. F. 1972, unpublished Ph.D. thesis, University of Western Ontario.
———. 1973, *Ap. J.* (in press).
Huchra, J. 1972, *Ap. J.*, **174**, 435.
Kemp, J. C. and Wolstencroft, R. D. 1973, *Ap. J.* (*Letters*), **179**, L53.
Preston, G. W. 1969, *Ap. J.*, **156**, 967.
Unno, W. 1956, *Pub. Astr. Soc. Japan*, **8**, 108.

Note added 1973 August 20.—Dr. Kemp has communicated to me that later data and more complete analysis (Kemp and Wolstencroft, to be published) show the presence of a small interstellar polarization in 53 Cam, sufficient to shift the measured polarization maxima away from the extrema of H_e. The problem posed in my concluding remark above is apparently therefore solved.

© American Astronomical Society • Provided by the NASA Astrophysics Data System