THEORETICAL SURFACE BRIGHTNESS DISTRIBUTIONS AND CONTINUUM POLARIZATION OF RAPIDLY ROTATING B STARS

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In order that a rotating star be in hydrostatic and radiative equilibrium, the effective temperature of the stellar atmosphere must decrease between the star's poles and its equator. Wavelength differences in this "gravity darkening" have been suggested to account for the observed differences in the rotational broadening of lines in the ultraviolet and visual spectral regions (hutchings, 1976; Sonneborn and Collins, 1977). This paper investigates the problem, using detailed model atmospheres to examine the surface brightness distribution of a rapidly rotating star.

The intensity distribution on the projected disk of a rapidly rotating B2 V star was computed for models with w=0.9 and 0.95 (V_{eq}=340km/sec and 384km/sec, respectively; $w=\omega/\omega_{crit}$) at wavelengths of 1325Å and 4400Å. The specific intensities were calculated for a grid of 1000 surface points from a model of the star's global atmospheric structure. The non-LTE, line-blanketed model atmospheres were computed with the ATLAS6 code (Kurucz, 1979). The models assume rigid rotation and use a Roche model for the shape distortion.

The isophote contours on the rotationally distorted star are shown in Figure 1. Important features of these results are: (1) The isophote topology in the visual and UV is nearly identical (cf. 1b and 1e). The severity of the UV "gravity darkening" compared with that in the visual is clearly demonstrated, since the UV contour interval is twice that in the visual. (2) The brightness distribution is a complex function of inclination. (3) The magnitude of the "gravity darkening" is a steep function of w (cf. 1b and 1d).

Since these brightness distributions are not spherically symmetric one expects the continuum to exhibit a net linear polarization due to electron scattering. The net polarization of rapidly rotating main-sequence stars (B0-B5) was computed using the methods described by Harrington and Collins (1968) and Collins (1972). The results are shown in Figure 2 for models with w=0.95, where the net degree of polarization is defined as $p = (I_\ell - I_r)/(I_\ell + I_r)$. I_ℓ and I_r are parallel

M. Jaschek and H.-G. Groth (eds.), Be Stars, 493–496.

https://doi.org/10.1017/S0074180900038249 Published online by Cambridge University Press

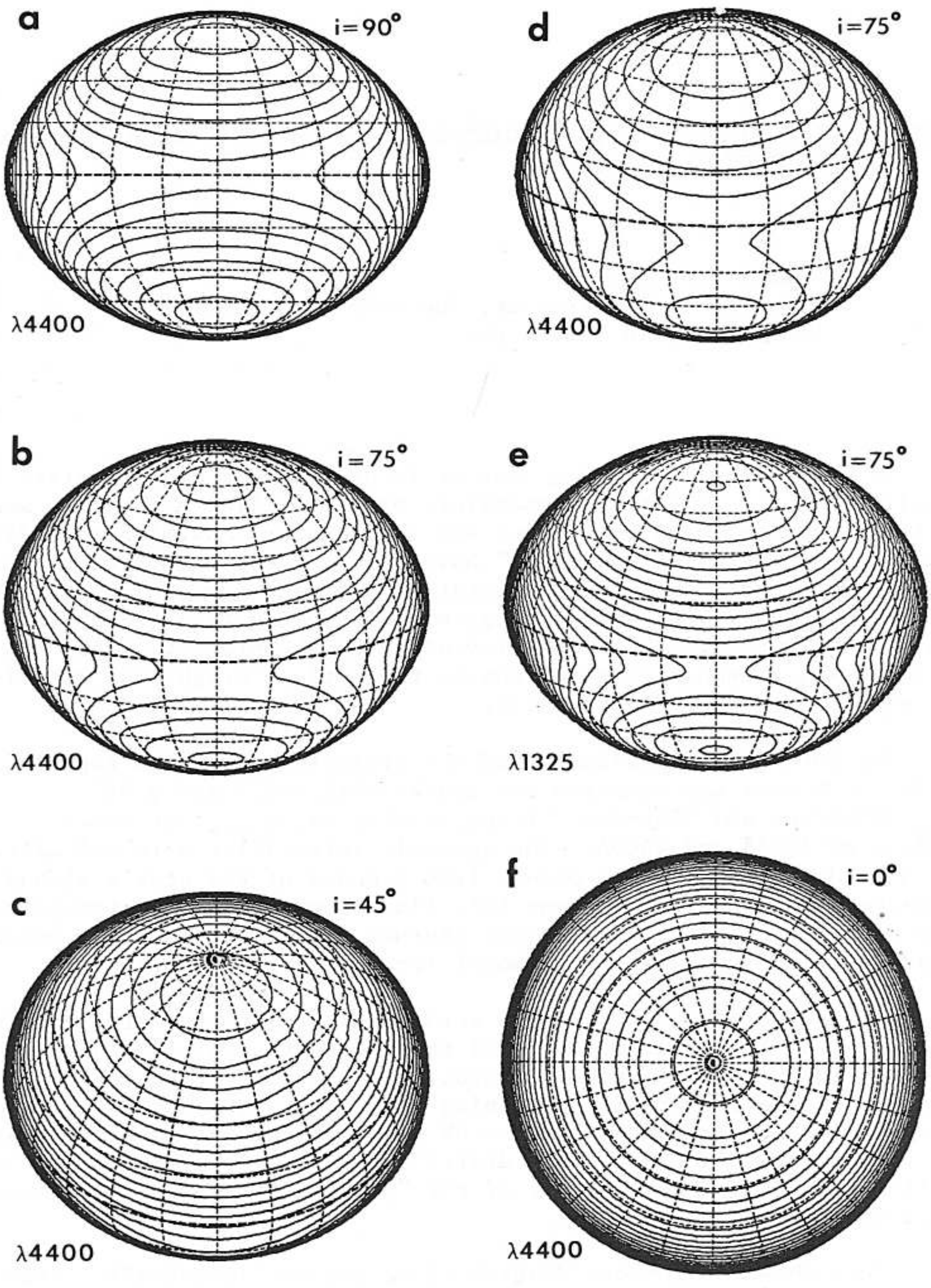

Figure 1. - Theoretical surface intensity distributions at 4400Å (except 1e, where λ=1325Å) for a B2 V star with w=0.95 (except 1d, where w=0.90) are shown for the indicated inclinations. The contour interval is 0.05mag at 4400Å and 0.1mag at 1325Å. A latitude - longitude grid with 15° intervals is also shown (dashed-lines).

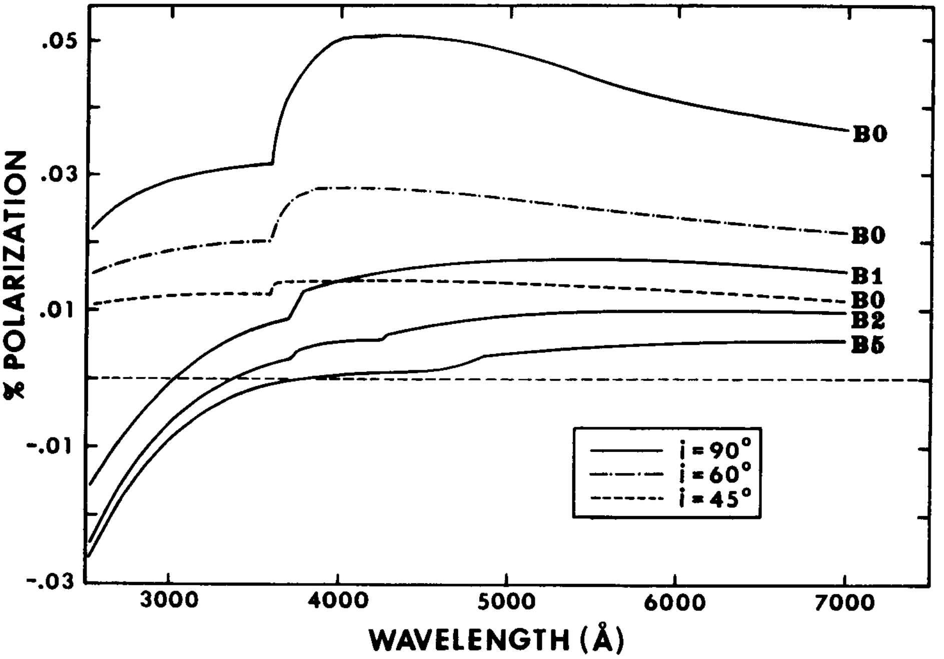

Figure 2. - The net linear polarization in the visual and near ultra-violet continua is shown as a function of wavelength for several rotation models, all with w=0.95. Zero polarization is shown by the thin dashed-line. The Balmer discontinuity coicides with the discontinuities in the B0 data.

and perpendicular, respectively, to the rotation axis. Figure 2 shows the continuum polarization to be up to a factor of 100 less than that found by Harrington and Collins (1968) for a gray atmosphere. Furthermore, p decreases into the UV and becomes negative. It is found that the UV continuum of rotation models viewed equator-on is polarized by -0.7% (B0, w=0.95) to -2.5% (B5, w=0.95). The large UV polarization is not surprising, in view of the extreme asymmetry of the UV surface brightness distribution. The extremely small visual polarization found for these models implies the observed continuum polarization in Be stars is not produced in the stellar photosphere.

The author wishes to thank the American Astronomical Society and the International Astronomical Union for financial assistance to attend Symposium No. 98.

Collins, G.W.,II.: Astrophys. J. 175, pp.147-156.
Harrington,J.P., and Collins,G.W.,II.: Astrophys. J. 151, pp.1051-1056.
Hutchings,J.B.: Pub.Astron.Soc.Pacific 88, pp.5-7.
Kurucz,R.L.: Astrophys. J. (Suppl.) 40, pp.1-340.
Sonneborn,G. and Collins,G.W.,II.: Astrophys. J. 213, pp.787-790.

DISCUSSION

Poeckert: If you had .1 A spectral resolution, what magnitude of polarization would you predict one might observe in the line?

Sonneborn: Unfortunately we have not yet looked at polarization across lines.

Endal: Are the Sackmann-Arand models you use in your calculations ZAMS models?

Sonneborn: Yes.

Metz: 1. A pole-on star is brighter and cooler as well compared to a star observed edge-on. Is that reproduced by your model?
2. Normally Be stars do not rotate at break-up velocity. Therefore the difference of polar and equatorial flux (according to von Zeipel) is too low to produce a relevant net polarization. Isn't that in contradiction to observations?

Sonneborn: 1. The discussion earlier (after Dr. Poeckert's review paper) on this subject concerned the effects of rotation and an equatorial disc. For a rotating star viewed pole-on will be bluer than the same mass star which is not rotating.
2. This is one of the points of this paper. The intrinsic polarization of a rotating star is much less than that observed in Be stars, implying that the observed polarization is produced completely in the circumstellar envelope.