CIRCUMSTELLAR CA II K LINES IN G, K AND M GIANTS AND SUPERGIANTS

by

A. H. Vaughan, Jr., and A. Skumanich

Mt. Wilson and Palomar Observatories
California Institute of Technology and
Carnegie Institute of Washington
Pasadena, California

and

High Altitude Observatory
*National Center for Atmospheric Research**
Boulder, Colorado

ABSTRACT

Tentative evidence, based on photoelectric observations of the Ca^+ emission core, is presented for the existence of circumstellar envelopes in several G and K type "giants." A significant emission asymmetry in α Tau may imply a chromospheric rather than a circumstellar source.

Key words: Ca^+ emission core, circumstellar absorption lines, late-type giants.

We present here a preliminary report of photoelectric scans of the cores of the CaII K line in several giant and supergiant stars. As Deutsch (1960) has pointed out, M "giants" - this term includes supergiants - have K emission cores on which are superimposed circumstellar (CS) lines. These are distinguishable from the K_3 chromospheric core

---

*The National Center for Atmospheric Research is sponsored by the National Science Foundation.

by "their very low central intensities ... and sometimes by their radial velocities as well." We believe that we have evidence for such CS lines in G and K "giants."

In Figures 1, 2, and 3 we present uncorrected scans averaged over several nights' observations of five "giants." We have plotted photon number (for a given count in the neighboring continuum) versus wavelength in arbitrary units (220 units = 1 Å). The instrumental resolution, instrumental half-width at half-maximum, was 0.14 Å (30 units).

The K emission profile is seen to be asymetric in both giants and supergiants. However, only in the supergiants does one find intensities for the "central" absorption feature which fall below the K_1 value. If one reflects the emission core about its bisector (i.e., if one "symmetrizes" the emission core) one obtains the dashed line indicated in the figures.**

The ratio of the observed intensity to that defined by the dashed line yields a measure of the strength of what we interpret as the CS line. These "absorption" depths are indicated in the top of the diagrams. Table 1 summarizes the equivalent width and wavelength shift for these CS lines.

The tabulated equivalent widths agree in magnitude and show the same increase with luminosity

TABLE 1

Star	Sp	W(Å)	-V km/sec	-V(W+B) km/sec
α Tau	K5 III	0.15	20	4
β And	MO III	0.20	21	16
β Peg	M2 II-III	0.31	4	6
ε Gem	G 8 I b	0.65	17	10
ε Peg	K 2 I b	0.47	26	28

** In the case of ε Gem and β Peg the circumstellar line was also symmetrized to obtain the complete dashed curve.

https://doi.org/10.1017/S0252921100151322 Published online by Cambridge University Press

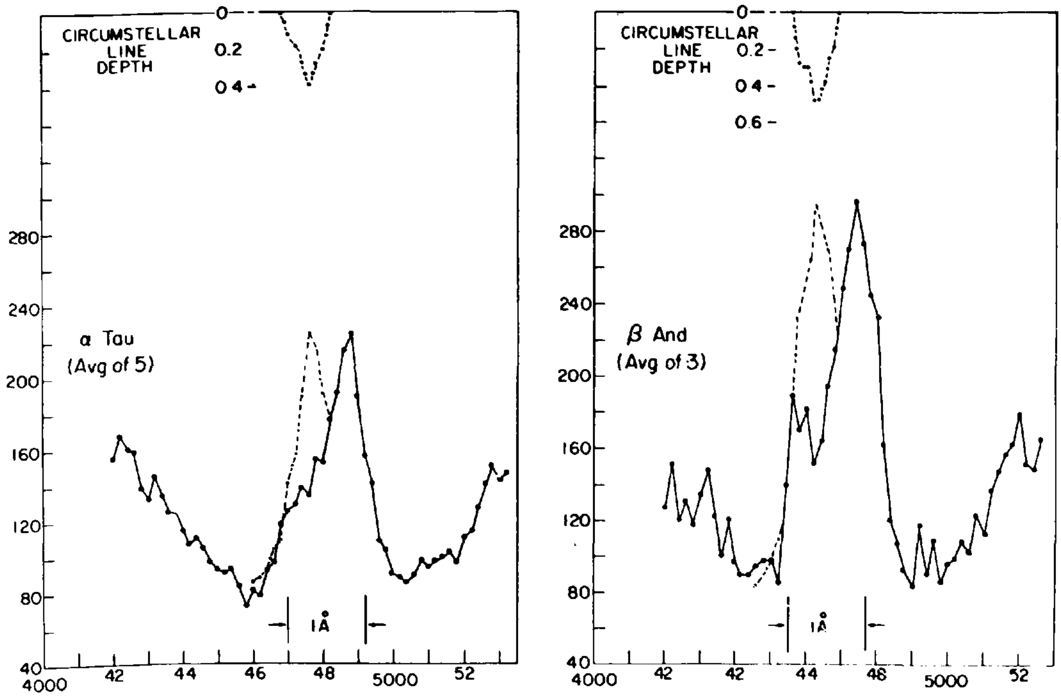

Figure 1. Averaged photoelectric scan of the K emission core (uncorrected for instrumental broadening). Photon count (for a given count in the neighboring continuum) versus scanner setting is represented. Wavelength increases to the right.

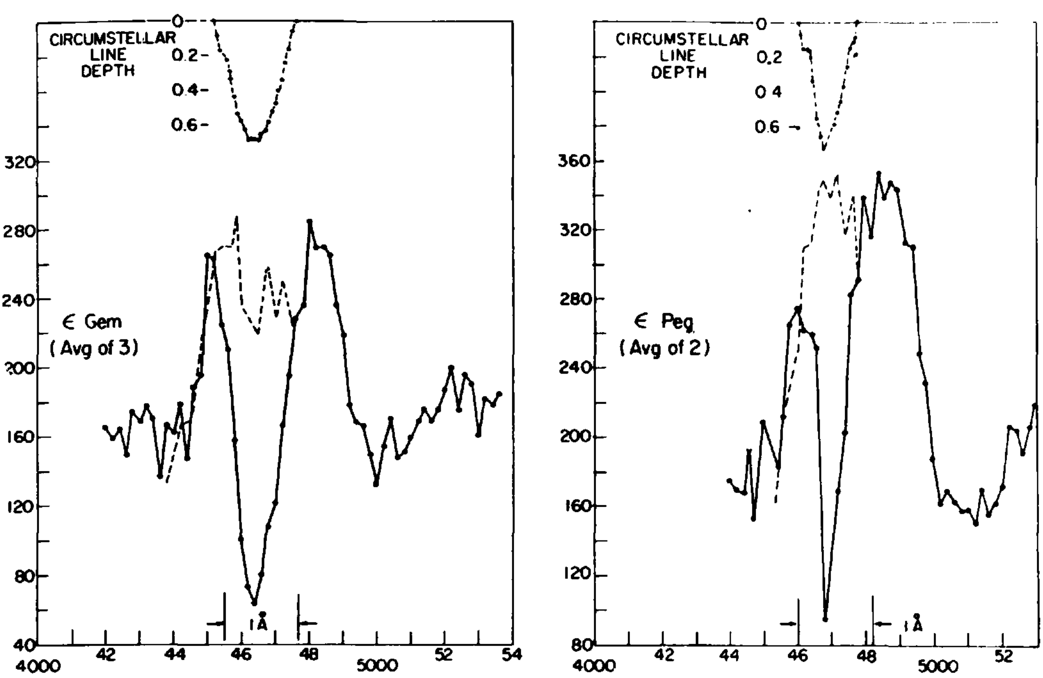

Figure 2. Data similar to Figure 1.

https://doi.org/10.1017/S0252921100151322 Published online by Cambridge University Press

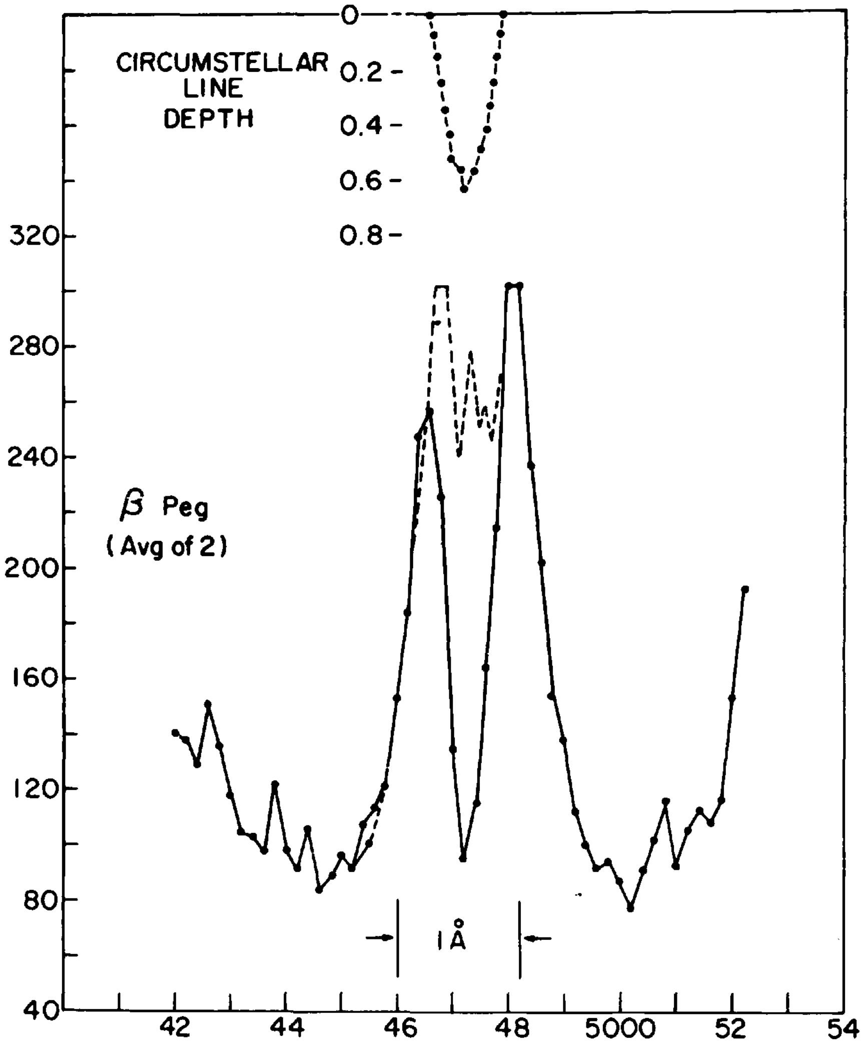

Figure 3. Data similar to Figure 1.

as in the later-type stars, Deutsch (1960). The wavelength shifts (relative to the emission bisector) indicate a nearly constant expansion of ≃ 20 km/sec except for β Peg. For comparison, we have given the shifts measured from spectral plates by Wilson and Bappu (1957). The agreement, except for α Tau, is fairly good.

An alternative explanation for the α Tau profile would be to allow an appreciable velocity gradient through the emission forming layers, cf. Weyman (1963). Such a gradient introduces an asymmetry with one side of the K_2 peak reduced (or eliminated) relative to the other, cf. Vaughan (1968) and Hummer and Rybicki (1968). Such an explanation would satisfy the statistical results (based on wavelength shifts) of Wilson (1960) which indicate no mass loss in class III stars earlier than MO. A complicating feature here is the evidence in the individual scans of α Tau of multiple weak dips in the depressed violet side. This raises the question of the significance of a mean profile. Thus, our results on α Tau should be viewed as tentative and may be changed by the more detailed investigation in progress.

REFERENCES

Deutsch, A. J. 1960, *Stellar Atmospheres: Stars and Stellar Systems, VI*, ed. J. L., Greenstein (Chicago: Univ. of Chicago Press), p. 543.
Hummer, D. G., and Rybicki, G. B. 1968, *Ap. J.*, 153, L107.
Vaughan, A. H., Jr. 1968, *Ap. J.*, 154, 87.
Weyman, R. 1963, *Ann. Rev. Astr. and Ap.*, 1, 97.
Wilson, O. C., and Bappu, M. K. V. 1957, *Ap. J.*, 125, 661.
Wilson, O. C. 1960, *Ap. J.*, 132, 136.

DISCUSSION

Pecker: Is it possible to distinguish between the effects of a chromosphere and those of circumstellar envelopes?

Skumanich: I would prefer an explanation by circumstellar envelopes. This is much simpler and will give a better fit of the line profile. This has already been shown by Deutsch.

Underhill: Have you observed the Na I D-lines by the same technique? If your interpretation of the absorption dips as circumstellar lines is correct, similar dips should be found in Na I, without the additional complication of emission components.

Skumanich: A slight doubling of the Na I D-lines is observed in the spectrum of α Ori; it can be interpreted as a circumstellar effect. In the spectra we have observed the effect is probably too small because the mass of the shell is not large enough. We have not tried to observe the effect.

Wellman: Several years ago I could show that the line doubling in α Ori is due to chromospheric effects.

Skumanich: The doubling of the Na I D-lines should be interpreted by circumstellar clouds. Chromospheric effects tend to wipe out the structure as Hummer has shown.