A SPECTROPHOTOMETRIC STUDY OF ε AURIGAE

The recent interpretation of ε Aurigae by Kuiper, Struve, and Strömgren[1] suggests that at long wave lengths the composite color of this binary system should be redder than that of a normal F supergiant. In other words, the infrared energy of the dark companion should, with increasing wave length, become larger with respect to the visually bright F star.

Becker[2] finds from photoelectric observations in the blue and violet that the color of ε Aurigae is normal for its spectral class (F_2). On the other hand, infrared observations of its color which I made at the Yale Observatory[3] in 1932 indicate a positive color excess of 0.20 mag. All these color observations were made outside of eclipse.

The results of more recent observations[4] are given in Table 1.

As a comparison star, α Persei was chosen, because its spectrum is similar to that of ε Aurigae; ε Leonis was also used, despite its somewhat unfavorable position in the sky, since its apparent magnitude and color are similar to those of ε Aurigae. Although all observations were made near the meridian, small differential extinction corrections were always applied. The slit widths correspond to a spectral range of 480 A. In the case of the comparison of α Persei with β Tauri (mentioned below) small differential corrections were applied to reduce these observations to the same effective wave lengths. The largest of these corrections was 0.02 mag.

The mean difference in magnitude between ε Aurigae and α Persei is plotted in Figure 1 against the reciprocal of the wave length. In the case of ε Leonis the individual values are shown.

If stars radiate as black bodies, the observed difference in magnitude between any two stars is very nearly a linear function of the frequency over the spectral range with which we are concerned. Jensen[5] has found, from a discussion of his own results and from

[1] *Ap. J.*, **86**, 570, 1937.

[2] *Veröff. Sternwarte Berlin-Babelsberg*, **10**, No. 3, 1933. [3] *Ap. J.*, **79**, 145, 1934.

[4] For method of making these observations see *ibid.*, **84**, 372, 1936, and **85**, 145, 1937.

[5] *A.N.*, **248**, 223, 1933.

TABLE 1

OBSERVED MAGNITUDE—DIFFERENCES

ϵ Aurigae *minus* α Persei

DATE	EFFECTIVE WAVE LENGTH												
	0.454μ	0.501μ	0.549μ	0.597μ	0.645μ	0.693μ	0.741μ	0.789μ	0.838μ	0.886μ	0.935μ	0.980μ	1.025μ
1938													
Jan. 18....	(1^m.26)	1^m.25	1^m.19	1^m.19	1^m.15	1^m.13	1^m.12	1^m.11	1^m.02	0^m.96	0^m.97	0^m.95	(0^m.96)
Jan. 23....	(1.23)	1.23	1.22	1.22	1.06	1.20	1.13	1.10	0.96	0.98	0.95	0.99	(0.88)
Jan. 26....	(1.36)	1.28	1.23	1.18	1.18	1.13	1.11	1.08	1.02	1.00	0.97	0.85	(0.96)

ϵ Aurigae *minus* ϵ Leonis

DATE	EFFECTIVE WAVE LENGTH												
	0.454μ	0.501μ	0.549μ	0.597μ	0.645μ	0.693μ	0.741μ	0.789μ	0.838μ	0.886μ	0.935μ	0.980μ	1.025μ
1938													
Jan. 26....	(−0^m.16)	−0^m.04	−0^m.02	+0^m.04	−0^m.02	+0^m.06	+0^m.04	+0^m.06	+0^m.02	−0^m.06	−0^m.02	−0^m.02	(−0^m.01)

DATE	EFFECTIVE WAVE LENGTH												
	0.478μ	0.525μ	0.573μ	0.621μ	0.669μ	0.717μ	0.765μ	0.813μ	0.862μ	0.910μ	0.958μ	1.000μ	
1938													
Feb. 7....	−0^m.20	−0^m.07	−0^m.03	+0^m.02	+0^m.07	0^m.00	+0^m.10	+0^m.10	−0^m.06	−0^m.06	−0^m.08	−0^m.09	

those of others, that the empirical data are best represented by two straight lines which intersect at 4800 A. It appears, therefore, that

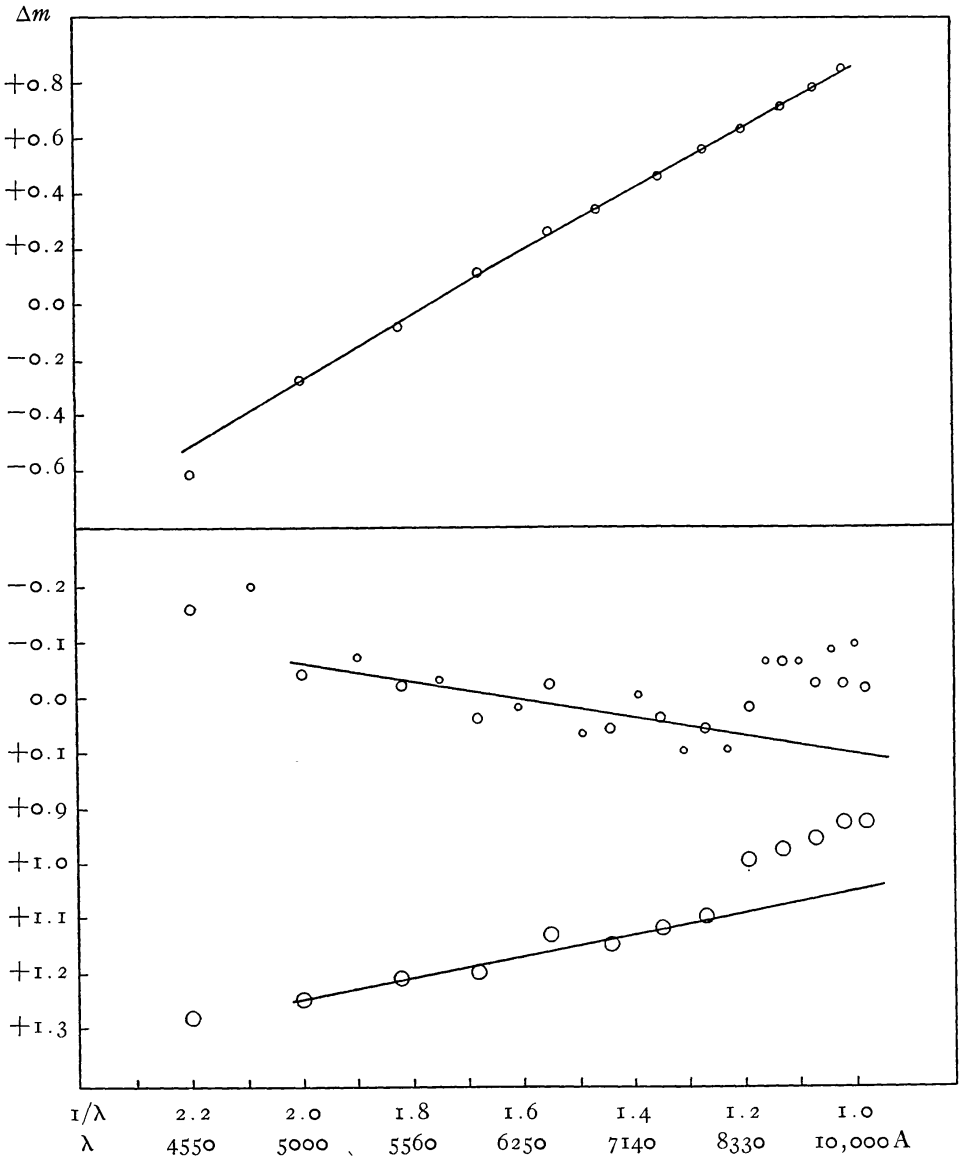

FIG. 1.—*Upper diagram:* β Tauri *minus* α Persei. *Lower diagram:* ϵ Aurigae *minus* ϵ Leonis and *minus* α Persei, respectively.

observations at less than 5000 A should not be used in deriving relative color temperatures in the red regions of the spectrum.

Since ϵ Aurigae is known to be a supergiant, it is, of course, desir-

able to know whether the excess infrared energy suggested by the color indices and by Figure 1 is not characteristic of stars of high luminosity. Becker and Hartwig[6] conclude, after a thorough discussion of Yale infrared colors and Babelsberg blue-violet colors, that in these spectral regions there is practically no such absolute-magnitude effect for stars whose spectral types range from F0 to F6. α Persei is also a supergiant. The observed difference in magnitude between α Persei and β Tauri (B8) is plotted against the reciprocal of the wave length in Figure 1. These data are the mean of determinations made on five different nights. The curved line has been computed on the assumption that the temperatures of these two stars are 6500° and 15,100°. This comparison indicates that α Persei is a normal star, and shows that the excess infrared energy of ϵ Aurigae would be indicated in the same degree had it been compared directly with β Tauri.

A comparison of ϵ Leonis with ϵ Geminorum was also made on February 7. Since a linear magnitude-frequency relationship was found to exist between these stars, it is probable that ϵ Leonis is also a normal star.

The data in Table 1 give no definite indication that the intensity of ϵ Aurigae has changed during the three-week interval represented by the observations.

Although ϵ Aurigae is in the galactic plane, it is difficult to explain the observed results on the basis of space reddening. In the first place, Becker's results show a normal color in the shorter wave lengths. Furthermore, Sproul observations[7] have shown that the observed difference in magnitude between a colored and normal B star is linear with the frequency. A comparison of infrared and blue-violet color indices by Bennett[8] gave a similar indication. More recently, Whitford[9] confirmed these results. These three discussions include a total of only 15 colored B stars; yet it seems significant that no obvious exception to this conclusion has been found.

If we assign half-weight to the comparison with ϵ Leonis, the excess energy of ϵ Aurigae is 0.13 mag. at 9600 A. If we assume that

[6] *Zs. f. Ap.*, **14**, 269, 1937.
[7] *Ap. J.*, **85**, 145, 1937.
[8] *Ibid.*, p. 275.
[9] Amer. Astr. Soc., December, 1937.