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DELTA SCORPII AN INFRARED DEFICIENT STAR AND THE VALUE OF R FOR THE SCORPIUS REGION

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SUMARIO

δ Sco es una estrella con tipo espectral B0 V y fue usada, entre otras, en una determinación anterior del valor de R para la región del Escorpión. En este trabajo se hace ver que δ Sco es una estrella peculiar con una notable deficiencia en el infrarojo. Se sugiere un nuevo valor de R para la región del Escorpión.

ABSTRACT

δ Sco, a B0 V star, was used among others in a previous determination of R for the Scorpius region. In this investigation it is shown that δ Sco is a peculiar star with a conspicuous infrared deficiency. A new value of R for Scorpius is suggested.

Introduction

The Scorpio-Centaurus group is one of the nearest associations. Its convergent point and its distance are known thanks to Bertiau's (1958) work. These determinations have made possible the calibration of the absolute luminosities of the members and as a consequence, the study of the colors of these stars and the interstellar reddening in the region should be of particular interest.

Two extensive photometric works, one by Borgman (1960), who used narrow-band photometry and another by Hardy and Crawford (1961) in which UBV plus H_β were employed, deal with the Scorpio-Centaurus group, specifically with, what Blaauw (1946) refers to as, the "Upper Scorpius Division". Observations of some members of the group in UBVRIJKL have been made by Johnson, Mitchell, Iriarte and Wisniewski (1966). Johnson (1968) used the aforementioned photometry in the determination of the value of R for Scorpius. The purpose of this work is a re-examination of the value of the ratio of total to selective absorption for Scorpius.

Observational Analysis

The colors and the color-excess ratios for δ Sco, β Sco AB, ω Sco, ν Sco, and σ Sco, that are shown in Table 1 and Table 2 respectively, were taken from Johnson's (1968) work without any change.

TABLE 1

Observational data

BS	*Star*	*Sp*	*V*	*U−V*	*B−V*	*V−R*	*V−I*	*V−J*	*V−K*	*V−L*
5953*	δ Sco	B0V	2.33	−1.01	−0.11	−0.01	−0.15	−0.23	−0.43	−0.48
5984/85	β Sco AB	B05V + B2V	2.55	−0.90	−0.08	−0.03	−0.11	−0.08	−0.23	−0.17
5993	ω′ Sco	B1V	3.98	−0.86	−0.04	0.06	−0.03	0.04	0.00	−0.05
6027*	ν Sco	B2 IV-V	4.02	−0.60	0.04	0.09	0.13	0.24	0.27	0.33
6084*	σ Sco	B1 III	2.88	−0.56	0.14	0.19	0.31	0.46	0.51	0.53

NOTES FOR TABLE 1

5953.—Spectroscopic Binary.
6027.—Double.
6084.—Spectroscopic Binary, 34.08 days, stationary Ca lines, β C. Ma variable.

In Table 2 it is noticed at first glance, that the color-excess ratios of δ Sco are significantly different in the infrared than the ones for the other stars in the group. In order to illustrate these differences, the mean values of the color-excess ratios of β Sco AB, ω′ Sco, ν Sco and σ Sco given in Table 3 are also shown in graphical form in Fig. 1, where the solid line refers to the mean over the four stars while the dashed line is that for δ Sco. The abscissae give the wave-number (and colors) and the ordinates are the color-differences.

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TABLE 2

Color-excess ratios for Scorpius

Star	$\frac{E_{U-V}}{E_{B-V}}$	$\frac{E_{B-V}}{E_{B-V}}$	$\frac{E_{B-R}}{E_{B-V}}$	$\frac{E_{V-I}}{E_{B-V}}$	$\frac{E_{V-J}}{E_{B-V}}$	$\frac{E_{V-K}}{E_{B-V}}$	$\frac{E_{V-L}}{E_{B-V}}$	E_{B-V}
δ Sco	1.95	1.00	0.63	1.37	2.47	2.63	2.47	0.19
β Sco AB	1.61	1.00	0.44	1.39	3.00	3.33	3.78	0.18
ω′ Sco	1.50	1.00	0.77	1.50	3.00	3.77	3.64	0.22
ν Sco	1.79	1.00	0.68	1.61	2.75	3.50	3.79	0.28
σ Sco	1.58	1.00	0.75	1.68	2.70	3.35	3.45	0.40

TABLE 3

Adopted mean color excess ratios for Scorpius

$\frac{E_{U-V}}{E_{B-V}}$	$\frac{E_{B-V}}{E_{B-V}}$	$\frac{E_{V-R}}{E_{B-V}}$	$\frac{E_{V-I}}{E_{B-V}}$	$\frac{E_{V-J}}{E_{B-V}}$	$\frac{E_{V-K}}{E_{B-V}}$	$\frac{E_{V-L}}{E_{B-V}}$
1.62	1.00	0.66	1.56	2.86	3.46	3.67

If the observations of δ Sco are correct, the difference obtained between the extinction curves lead us to the conclusion that δ Sco is a peculiar star and, therefore, should be excluded from the group. From the mean values of the color-excess ratios in Table 3 and from the solid line in figure 1 a value of R $\simeq$ 3.8 was deduced for the region of Scorpius.

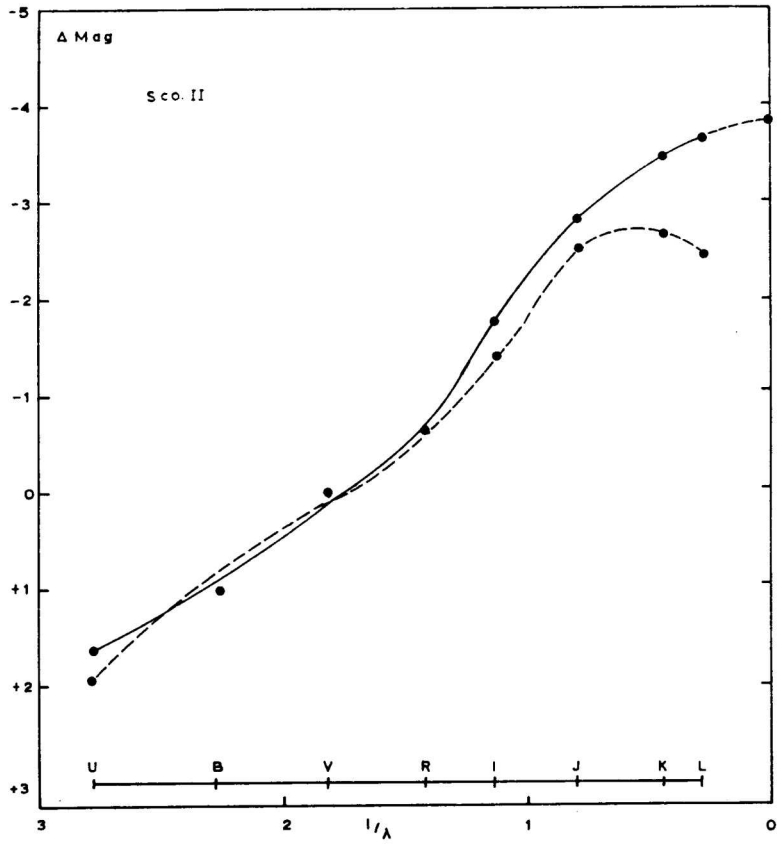

Fig. 1.—*The solid line represents the interstellar extinction curve for Scorpius determined from the mean values of the color-excess ratios of β Sco AB, ω′ Sco, ν Sco and σ Sco. The dotted line represents the interstellar extinction curve for Scorpius determined from the color-excess ratios of δ Sco alone.*

Let us go further in the analysis of δ Sco, a B0V star, which as we emphasized above appears to be abnormal in the infrared; first, we can correct the observed values for interstellar reddening and then we can compare them with the corresponding intrinsic colors for its spectral type. The results are illustrated in Figure 2. The straight-line represents the intrinsic color of a B0V star. By inspection of the plot it is obvious that δ Sco has a striking deficiency in the infrared for its spectral type. The probable errors of the observations for δ Sco in K, J–K, K–L for a single observation are: ±0.05, ±0.03, and ±0.04 respectively and from them we can say that the infrared deficiency of δ Sco cannot be imputed to observational errors.

There are some arguments that can be given to explain this anomaly in the energy-distribution curve of δ Sco, namely, that the spectral type could be earlier, however, δ Sco is a B0V standard for this particular class (Johnson and Morgan, 1953); moreover, according with Johnson's (1968) intrinsic colors of early-type stars, no normal O or B type star has a V–L color-index greater than –0.92. Once corrected for interstellar reddening δ Sco has a V–L = –1.18. Another possible cause for this peculiarity may be inherent in Johnson's intrinsic colors; but it seems improbable that this is the case.

At this point it seems quite certain that δ Sco is a peculiar star that shows deficiency in the infrared. Johnson (1969) called my attention to another star that shows the same peculiarity as δ Sco, namely Sirius, the brightest in the sky. Following the same procedure used for δ Sco and from data published by Johnson *et al.* (1966) the color-excesses for Sirius were computed, and the results plotted in Figure 3. The straight-line represents the intrinsic colors for an A1 V star; we note that Sirius also presents a deficiency in the infrared.

Up to now, we have let aside in our analysis the UBV part of figures 2 and 3; however, it is interesting to notice that δ Sco and Sirius show ultraviolet-excess, which is more conspicuous in the case of the latter star.

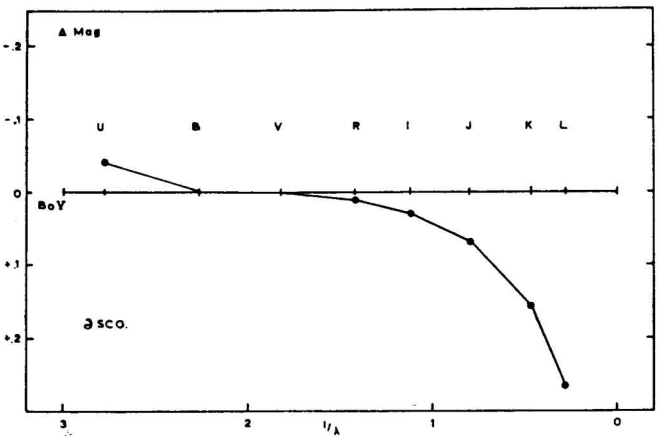

Fig. 2.—*The spectral energy-curve for δ Sco. The data is relative to that of an BO V star.*

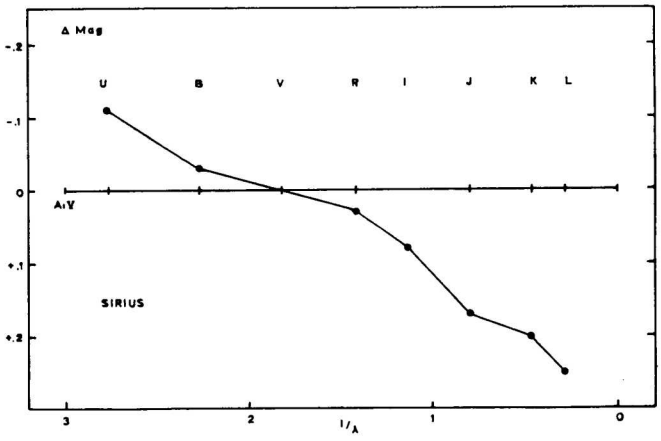

Fig. 3.—*The spectral energy-curve for Sirius. The data is relative to that of an A1 V star.*

Conclusion

We have called attention to two very bright stars which exhibit energy distribution curves that are anomalous for their spectral types. It is not the purpose of this note to give an explanation for these anomalies; we only wish to emphasize that certain problems related to interstellar reddening need to be trated more thoroughly, not because the methods and observational techniques that have been used are inadequate, on the contrary, they are excellent but because account should be taken of the presence of unknown characteristics in the energy-distribution of some stars, characteristics which are being disclosed by modern infrared techniques.

The value of R for Scorpius given previously in this work should be considered doubtful because the deficiency in V–L for σ Sco, after correction for reddening, is 0.13 mag a value which is certainly not negligible.

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