INFRARED OBSERVATIONS OF STARS IN THE ASSOCIATION CYG OB2

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Abstract. About 80 stars of the association Cyg OB2 have been observed in *J*, *H*, *K* and *L*. These measurements have been made in search for infrared circumstellar emission in this highly reddened association.

1. Introduction

The most highly reddened association Cyg OB2 in the northern sky, in which Schulte (1956, 1958) has found a large number of OB stars, has been investigated thoroughly by Reddish *et al.* (1966). They used a photographic UBV-photometry with limiting magnitudes of $16\overset{m}{.}5$ in *B* and $15\overset{m}{.}7$ in *V*. These authors concluded that the high visual absorption (up to about 10^m) is caused mainly by dust clouds associated with the individual stars. They come to the result that about 60% of the total association mass is in circumstellar shells. The age of the association is estimated to be less than 10^6 yr. There exist so far observations in the infrared only for a few very bright members of the association. We observed approximately 80 stars of different visual magnitudes from Reddish's catalogue in the infrared in order to look for circumstellar emission.

2. Observations

Our measurements were made in the four broadband filters *J*, *H*, *K* and *L* in the spectral range from 1.2μ to 3.5μ with the 50″ telescope at Kitt Peak. In addition several stars also were observed at 5μ and 10μ, but they were too faint for detection. The observed stars were selected according to the following criteria:

(1) OB stars identified spectroscopically by Schulte (1956, 1958) with large color-excesses E_{B-V}.

(2) other stars unambiguously of early spectral type (earlier than B3) taken from the $U-B/B-V$ diagram, also with large color-excesses.

(3) several stars later than A0 and stars of different spectral types with small color-excesses.

Figure 1 shows the $U-B/B-V$ diagram of the observed early type stars with color-excesses roughly between $1\overset{m}{.}0$ and $2\overset{m}{.}8$ and the normal reddening line. Schulte's spectral classification and UBV spectral types are in good agreement.

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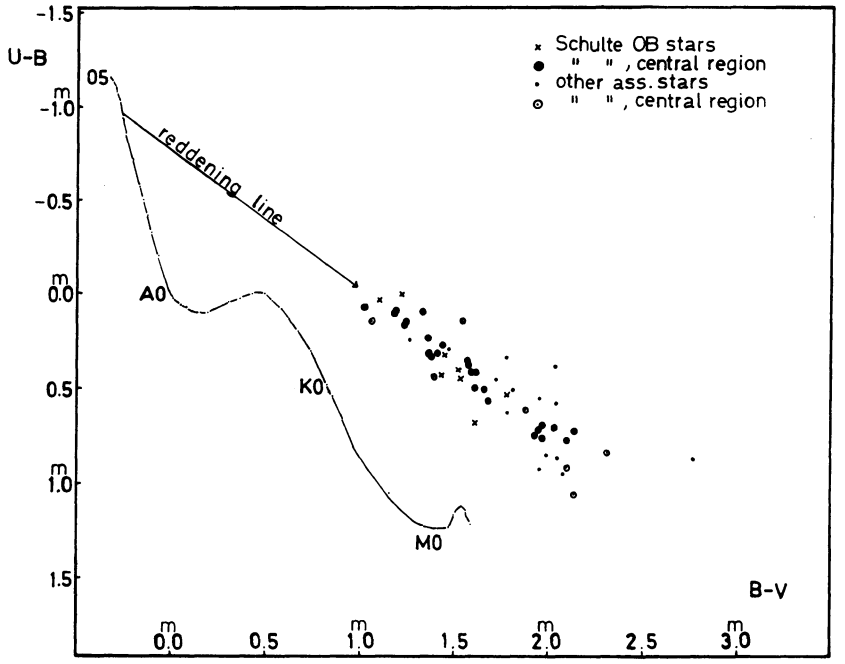

Fig. 1. $U-B/B-V$ diagram for most of the observed stars. The different symbols mark Schulte's OB stars and other association stars inside and outside the central part of the association. The unreddened main-sequence and the reddening line also are shown.

The question now arises whether or not these high absorption values are produced inside the association itself. From Reddish's two-color diagram for all his observed stars (more than 1200) we obtain a minimal value $A_V \approx 2$ mag. for the foreground absorption. The catalogue of early type stars by Ikhsanov (1959) yields a crude estimate of 3 mag. visual absorption within a distance of 2.1 kpc, the adopted distance of the association Cyg OB2. Field 30 of Neckel's catalogue (Neckel, 1967) gives $A_V = 2\overset{m}{.}6$ within 2 kpc. As an average we adopt an absorption A_V of about $2\overset{m}{.}5$ in the line of sight to the association.

Most of the stars observed by us lie in the central region of the association where the visual absorption and OB star density are highest. In Figure 2 the lines of high constant absorption in this inner part are shown. It clearly stands out against the surroundings. The major axis of these ellipsoids is coincident with the axis of the ellipsoid of highest star density. This also confirms the fact that most of the extinction takes place within the association.

The indicated values for A_V are based on $R \equiv A_V/E_{B-V} = 3.25$. R has been obtained by extrapolating $(1/\lambda \to 0)$ our infrared data of about 22 stars with spectral types deduced from objective prism classification. Figure 3 shows our extinction curve vs wavelength. Not a single star indicates a value of R significantly different from 3.0 in contrast to the large values of R found by Strom *et al.* (1972) in the young cluster NGC 2264.

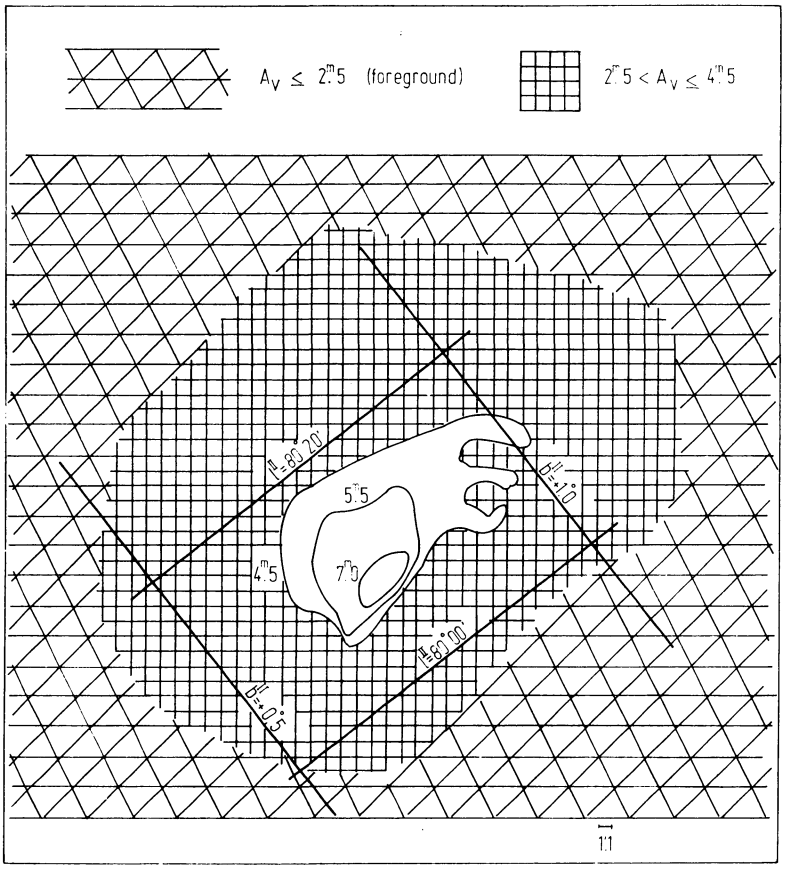

Fig. 2. Lines of constant high absorption in the central part of the association Cyg OB2, where most of Schulte's OB stars are concentrated. Foreground absorption A_V amounts to approximately $2^m.5$.

Figure 4 represents the $V-L/B-V$ diagram for 35 of the observed stars for which L measurements were possible. The colors all can be explained by extinction according to the known interstellar law. There is no infrared excess (including even the extremely reddened OB star Schulte No. 12) that would indicate circumstellar shell emission.

For only one star (Reddish-catalogue No. 662) with $V = 15^m.6$ there could be found an excess in K (2.2 μ) of about $3^m.5$. Unfortunately this measurement is not very reliable because it is near the limiting magnitude in K; the other infrared colors have not been measured.

3. Conclusion

Our conclusion therefore is that the stars brighter than $V = 15^m.6$ have no circumstellar shells within the usual temperature range from 700 to 1000 K. We are inclined to interpret the correlation found by Reddish, namely that the absolutely brighter

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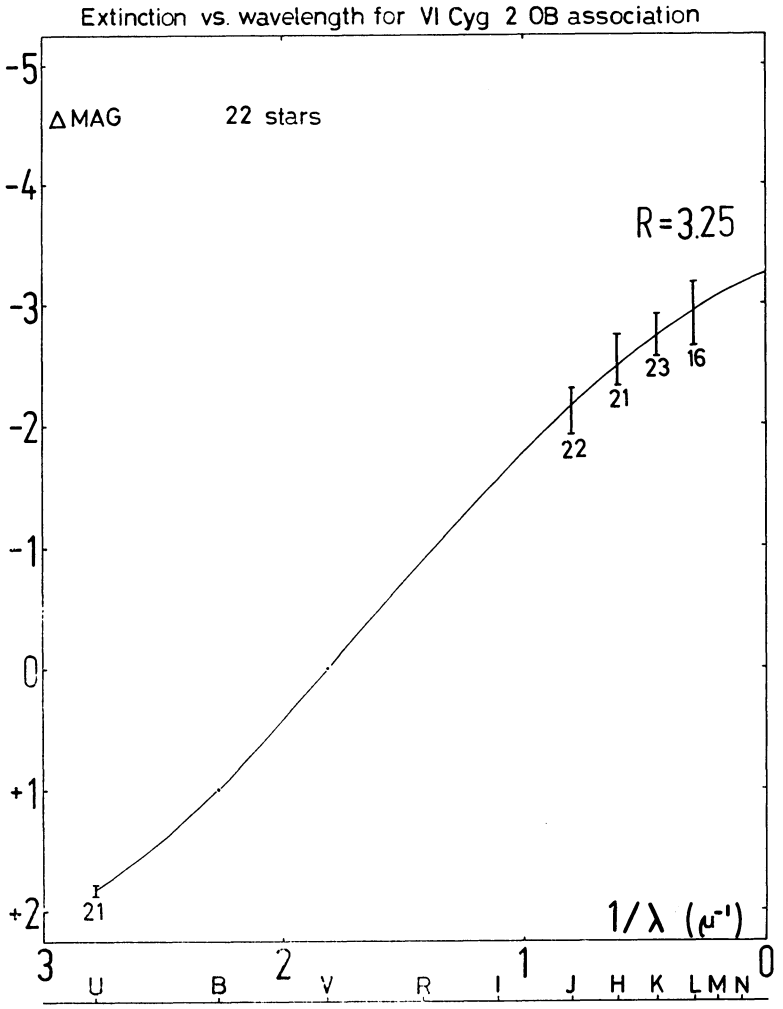

Fig. 3. Mean normalized extinction curve vs $1/\lambda$. The numbers of stars with known spectral types measured in different colors are given below the error bars.

stars have larger color-excesses E_{B-V}, rather by the fact that these stars are located in the densest regions of the dust cloud out of which they have been formed and not by the existence of circumstellar shells with variable optical depth. It might however be that these bright stars already have lost their original thick shells that could have formed according to current models of pre-mainsequence evolution (Larson, 1969, 1972). Then the question arises whether or not circumstellar emission might be found for the stars fainter than $V = 15\overset{m}{.}7$.

On sensitized IN plates ($\lambda_{\text{eff}} \approx 0.8\ \mu$) taken of this association at Heidelberg we were able to identify approximately 20 very faint ($V > 16\overset{m}{.}0$) and extremely red objects with $B-V \geqslant 2\overset{m}{.}5$, which need further photoelectric observations at longer wavelengths.

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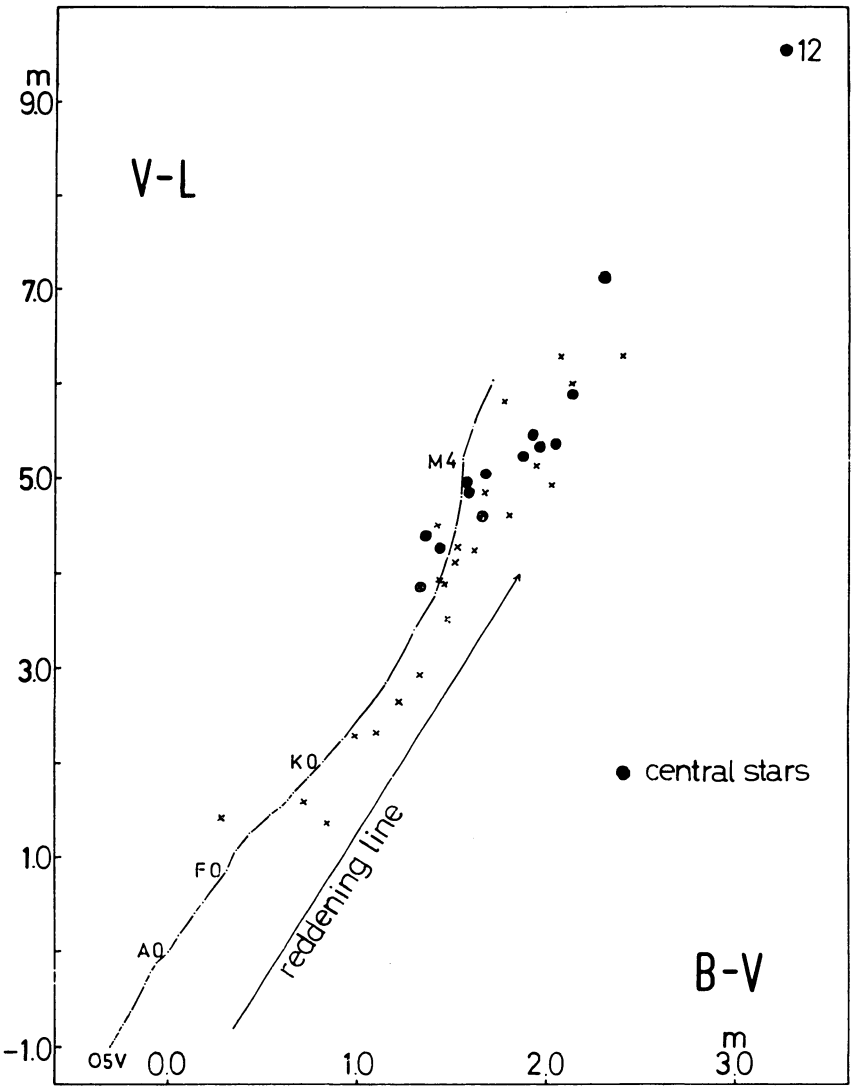

Fig. 4. $V-L/B-V$ diagram for the stars inside (●) and outside the central part. The unreddened main-sequence and the reddening line are shown. Not a single star (including the extremely reddened OB star Schulte No. 12) has a significant L-excess.

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