1968ApJS...15..459G

A PHOTOMETRIC INVESTIGATION OF THE SCORPIO-CENTAURUS ASSOCIATION*

ADELINA GUTIÉRREZ-MORENO† AND HUGO MORENO
Departamento de Astronomía, Universidad de Chile
Received March 23, 1966; revised June 5, 1967

ABSTRACT

UBV colors and magnitudes are given for 251 stars in the region of the Scorpio-Centaurus association. Intrinsic colors and magnitudes corrected for interstellar absorption are computed by Johnson's *Q* method.

The presence of strong differential reddening in a restricted area permitted an estimation of the ratio of total to selective absorption, which seems to be abnormally high for this zone.

Absolute magnitudes were computed using moving cluster parallaxes. Luminosity calibration curves against both colors are given for all stars with known distance moduli. A study of the possible membership of the association is made for all program stars.

Hβ observations were made for all stars brighter than 6.5 which were retained as members or probable members from three-color photometry; using Hardie and Crawford's calibration, new distance moduli were determined from the β values. The group has an elongated shape, making an angle of about 18° with the galactic plane.

I. INTRODUCTION

The Scorpio-Centaurus association is a well-known group of B-type stars, especially appropriate for the investigation of the characteristics of young stars; the calculation of stream parallaxes of its members provides a fundamental method for the determination of absolute magnitudes and, consequently, for the calibration of luminosities.

The association is a part of the Gould Belt of early-type stars and interstellar matter. According to Blaauw (1946, 1964), its boundaries lie approximately between $l^{\mathrm{I}} = 330°$ and 280° ($l^{\mathrm{II}} = 2°$ and 312°) and $b^{\mathrm{I}} = +5°$ and $+25°$ ($b^{\mathrm{II}} = +5°$ and $+26°$), at least insofar as the brighter stars are concerned; it probably extends down to $l^{\mathrm{I}} = 240°$ ($l^{\mathrm{II}} = 272°$), but at this part there is not a well-defined boundary and the association merges gradually into the field B-star population. The determination of membership, necessary to derive a useful calibration of luminosities, is difficult at the low-longitude end and is further complicated by the fact that several subsystems may be distinguished in the association, as the "Upper Scorpius" region (Blaauw's area 2); "Upper Centaurus–Lupus" (area 3); and, less evident, "Lower Centaurus–Crux" (area 4).

A number of investigators have studied this group of stars because of its nearness and significance. A complete list of references may be found in the papers by Blaauw (1946, 1964) already quoted and by Bertiau (1958). Nevertheless, a thorough photometric investigation was lacking up to 1961, when Hardie and Crawford (1961) published a photometric study, including *UBV* and Hβ photometry of stars earlier than A0 (HD types) lying in the northern part of the association, which can be observed from the Dyer and McDonald observatories and which corresponds roughly to the Upper Scorpius region. The present work extends the photoelectric investigation, in *UBV* and Hβ, to the southern part of the association, including again the Upper Scorpius region, since the conditions under which the observations can be made from Cerro Tololo Inter-American Observatory are most favorable and practically all the stars can be observed with an air mass close to 1. The new data allow the study of the probable membership of the stars observed and increase the knowledge of interstellar absorption and reddening in

* *Publication of the Goethe Link Observatory*, Indiana University, No. 80.

† A portion of this work was this author's doctoral thesis.

the region of the sky covered by the association, particularly with regard to the distribution of the absorbing clouds and the ratio of total to selective absorption.

II. THE PROGRAM AND OBSERVATIONS

The program included all certain, probable, and doubtful members of the association according to Blaauw (1946); all stars listed in Bertiau's paper (1958), including thirty-seven faint stars in the Upper Scorpius region; twenty-five stars with spectral types B6 or earlier and distance moduli between 5.0 and 8.5, taken from Morris' list (1961); all stars not included in the preceding references and listed by Oosterhoff (1951), Crawford (1958), Buscombe and Morris (1960), and Hardie and Crawford (1961) and, in Blaauw's region 3, a few faint late B-type stars. Twelve double stars were eliminated from the program on account of their small separation.

The observations were made by H. Moreno at the Cerro Tololo Inter-American Observatory near La Serena, Chile, during the periods May–August 1962 and May 1963 (*UBV* photometry) and May–June 1964 (Hβ photometry). A 16-inch reflector equipped with a photoelectric photometer of conventional design and with a 1P21 unrefrigerated phototube was used.

TABLE 1

EXTINCTION STARS

HD	Name	Spectral Type	$(B-V)$	$(U-B)$	V	n
4128	β Cet	K1 III	+1.023	+0.849	2.061	23
74006	β Pyx	G4 III	+0.941	+0.640	3.977	57
74575	α Pyx	B2 II	−0.183	−0.885	3.685	46
75691	γ Pyx	K4 III	+1.284	+1.368	4.023	55
143018	π Sco	B1 V	−0.187	−0.918	2.890	49
143275	δ Sco	B0 V	−0.124	−0.920	2.307	69
148898	ω Oph	Ap	+0.135	+0.132	4.454	84
151680	ϵ Sco	K2 III–IV	+1.150	+1.147	2.310	19
189103	θ' Sgr	B3 IV	−0.150	−0.686	4.369	37
197692	ψ Cap	F5 V	+0.423	−0.027	4.140	39
225132	2 Cet	B9 IV	−0.048	−0.117	4.559	22

The procedure followed in the photoelectric observations and reductions was the same as that used by most of the investigators, with special care taken in the determination and elimination of the systematic errors affecting the observations. These corrections include not only the atmospheric extinction but also the red leak in the ultraviolet filter, the change of sensitivity of the equipment during long or short periods (during the night, from one night to the other, or even from one month to another), and the change of spectral sensitivity caused by possible variations in the optical elements.

Corrections were also applied to take into account the important fact that the sensitivity of the photomultiplier has a large wavelength-dependent temperature coefficient (Young 1963). For the *UBV* system these temperature effects are important in the visual region and affect the color $B - V$, making the star look redder at higher photocell temperatures. Our observations give a temperature coefficient of 0.001 mag/°F, independent of the color of the star; this value is about one-half of that predicted by Young.

The extinction coefficients for the period May–August 1962 ranged as follows: k_v = 0.09–0.16 mag, k_{bv} = 0.093–0.105 mag, k_{ub} = 0.285–0.309 mag, where k_v, k_{bv}, k_{ub} are the constant terms of the extinction in V, $B - V$, and $U - B$, respectively. The extinction was found to be constant all over the sky insofar as it could be determined from the observations; that is, no east-west difference was found.

The observations made during May 1963 showed the influence of the volcanic ash produced by the eruption of Mount Agung, Bali, on March 17, 1963 (Moreno and Stock 1964). The ranges of the extinction coefficients for this period were $k_v = 0.11$–0.45, $k_{bv} = 0.07$–0.11, and $k_{ub} = 0.301$–0.325.

Table 1 lists the stars used for extinction determinations: it gives the HD number, name and MK spectral type, the $(B - V)$ and $(U - B)$ colors, the magnitude V in the standard system, and the number of observations for each star.

The following linear expressions were used to make the transformation to Johnson and Morgan's standard system:

$$\begin{aligned} (B - V) &= 1.020(\pm 0.003)C_{by} + 0.906(\pm 0.002) \quad \text{(p.e.)}\,, \\ (U - B) &= 0.974(\pm 0.002)C_{ub} - 0.987(\pm 0.003) \quad \text{(p.e.)}\,, \\ V &= Y - 0.014(\pm 0.004)C_{by} - 1.090(\pm 0.003) \quad \text{(p.e.)}\,. \end{aligned} \tag{1}$$

TABLE 2

JOHNSON STANDARD STARS

HD	Name	Spectral Type	$(B-V)_J$	$(B-V)$	$(U-B)_J$	$(U-B)$	V_J	V	n	Remarks*
87901...	α Leo	B8 V	−0.11	−0.105	−0.36	−0.370	1.36	1.370	19	Ex
91316...	ρ Leo	B1 Ib	−0.14	−0.150	−0.95	−0.948	3.85	3.840	21	Ex
102870...	β Vir	F8 V	+0.55	+0.553	+0.10	+0.090	3.61	3.604	7	
106625...	γ Crv	B8 III	−0.11	−0.099	−0.35	−0.339	2.60	2.584	9	
116658...	α Vir	B1 V	−0.23	−0.241	−0.94	−0.949	0.96	0.986	15	Va
135742...	β Lib	B8 V	−0.108	−0.106	−0.37	−0.359	2.61	2.620	25	
140573...	α Ser	K2 III	+1.168	+1.163	+1.24	+1.239	2.65	2.638	7	
149757...	ζ Oph	O9.5 V	+0.02	+0.009	−0.86	−0.866	2.56	2.568	31	
161096...	β Oph	K2 III	+1.16	+1.167	+1.24	+1.232	2.77	2.771	13	
168723...	η Ser	K0 III–IV	+0.94	+0.940	+0.65	+0.659	3.26	3.276	5	
188512...	β Aql	G8 IV	+0.86	+0.854	+0.48	+0.480	3.71	3.738	12	SV
196867...	α Del	B9 V	−0.06	−0.054	−0.22	−0.212	3.77	3.767	9	
198001...	ϵ Aqr	A1 V	+0.01	+0.009	+0.04	+0.038	3.77	3.776	10	
218045...	α Peg	B9 V	−0.05	−0.039	−0.06	−0.054	2.49	2.492	13	

* Remarks: Ex, used also as extinction star; Va, variable star; SV, suspected variable.

Table 2 lists the standard stars used to compute these transformation equations. It gives the star's HD number, name and MK spectral type, the $(B - V)$ and $(U - B)$ colors and the magnitudes V as given by Johnson (Johnson and Morgan 1953; Johnson and Harris 1954) and computed by us, the total number of observations for each star and a list of remarks.

The stars α Vir and β Aql were not used for the transformation of the magnitudes because of their variability.

The average probable errors for the standard and extinction stars are

$$\epsilon_{(B-V)} = \pm 0.001 \text{ mag}\,, \qquad \epsilon_{(U-B)} = \pm 0.001 \text{ mag}\,, \qquad \text{and} \qquad \epsilon_V = \pm 0.002 \text{ mag}\,.$$

We can compare the accuracy of Johnson's values with our own, by computing $\sqrt{(\epsilon_J^2 + \epsilon_M^2)}$ and comparing it with the external probable error of our values with respect to the standard ones; this external probable error was determined from the real scatter of our observations with respect to theirs, as shown by the residuals in Figure 1. The results are given in Table 3. The comparison seems to indicate that Johnson's probable errors are smaller than the values he gives, since in all cases the external error is smaller than the quadratic sum of his errors and ours.

The catalogue for all observed stars is given in Table 10 (see below), which includes the same data as Table 1, except for the spectral types. The colors are given with three decimals and the magnitudes with only two, since the probable errors are larger for the last quantities. The internal probable errors for one observation of the catalogue stars are

$$\epsilon_{(B-V)} = \pm 0.005 \text{ mag}, \quad \epsilon_{(U-B)} = \pm 0.005 \text{ mag}, \quad \text{and} \quad \epsilon_V = \pm 0.011 \text{ mag}.$$

A comparison was made between our results and those given by Hardie and Crawford (1961) and Cousins and Stoy (1963) (cf. Fig. 2). The results are summarized in Table 4,

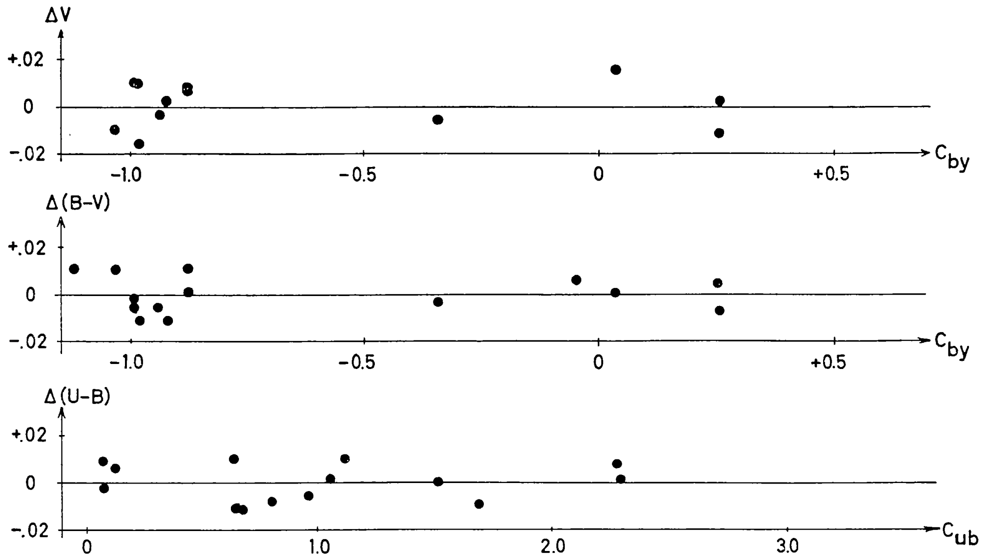


FIG. 1.—Differences (Johnson − Moreno) for the colors and magnitudes of the standard stars plotted against the instrumental colors.

TABLE 3

OBSERVATIONAL ERRORS: COMPARISON WITH JOHNSON

	$\sqrt{(\epsilon_J^2+\epsilon_M^2)}$	External Error
$B-V$..........	±0.006	±0.005
$U-B$..........	± .012	± .005
V.............	±0.012	±0.007

TABLE 4

OBSERVATIONAL ERRORS: COMPARISON WITH HARDIE-CRAWFORD AND COUSINS-STOY

	HARDIE AND CRAWFORD			COUSINS AND STOY		
	Mean Dif. ($M-HC$)	$\sqrt{(\epsilon_{HC}^2+\epsilon_M^2)}$	Ext. Error	Mean Dif. ($M-CS$)	$\sqrt{(\epsilon_{CS}^2+\epsilon_M^2)}$	Ext. Error
$B-V$..........	−0.01	±0.007	±0.010	0.00	±0.010	±0.009
$U-V$..........	− .01	± .009	± .013	− .03	± .010	± .013
V.............	0.00	±0.010	±0.013	+0.01	±0.010	±0.013

which gives the mean differences between their values and ours and the comparison of the internal and external probable errors, obtained after removing the systematic differences.

III. THE RESULTS

Unreddened colors were determined by the improved Q method, as given by Johnson (1958). For stars with peculiar spectra or luminosity class I or II, the intrinsic colors given by Johnson (1958) were used. Spectral types S_Q were determined for all stars of luminosity classes III–V, by means of the table given in the same paper, which relates spectral types with the Q value. Finally, the interstellar absorption for visual light was computed by means of the relation between the color excess for $(B - V)$ and the absorption

$$R = \frac{A_V}{E_{B-V}} = 3.0 \pm 0.2 \text{ (p.e.)} \tag{2}$$

given by Hiltner and Johnson (1956).

All these data are given in Table 11 (see below), where the first eight columns give the HD number of the star, the intrinsic colors $(B - V)_0$ and $(U - B)_0$, the visual magnitude V_0 corrected for interstellar absorption, the photometric spectral type, S_Q, and the spectral types and luminosity classes taken from Bertiau (1958), de Vaucouleurs (1957), and Morris (1961).

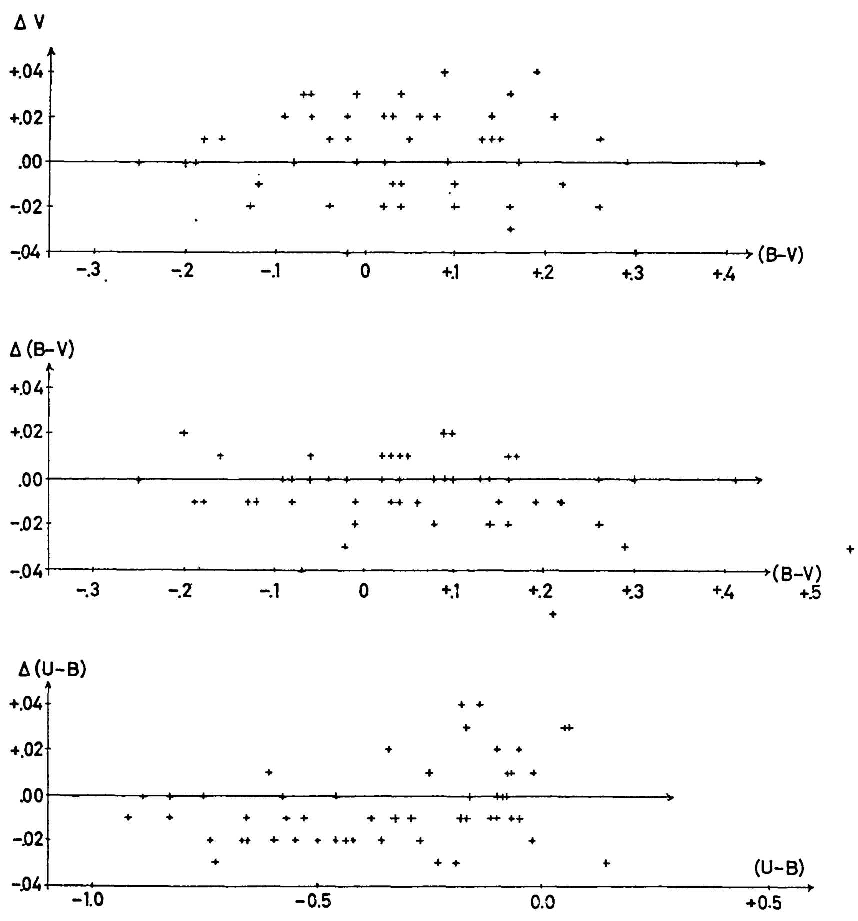


FIG. 2.—Differences (Moreno-Hardie — Crawford) for V, $(B - V)$, and $(U - B)$ plotted against the colors.

A comparison was made between the spectral types S_Q and the MK classifications given in the catalogue. The results are given in Figure 3, which plots the difference $\Delta S = (\mathrm{MK} - S_Q)$ for the three authors already mentioned, expressed in tenths of a spectral type. Table 5 summarizes the number of stars and the mean ΔS for each MK spectral type.

The S_Q types are, in the mean, earlier than the MK types, and this effect is larger for the later B stars, with a maximum about B6–B8. This trend is common to all three authors, even though de Vaucouleurs's types have a tendency to be later than Bertiau's around B2. The total range of ΔS goes from -3 to $+5$ subclasses. The stars showing the largest differences are:

HD 105382: S_Q = B3, Bertiau = dB7:, de Vaucouleurs = B6 III–IV ;
HD 139160: S_Q = B5, Bertiau = B8 V, Morris = B9 IV ;
HD 142301: S_Q = B3, Bertiau = B7 IV, Morris = B8 IV ;
HD 142990: S_Q = B3, Bertiau = B3: V, Morris = B8 V ;
HD 144334: S_Q = B4, Bertiau = B9: III, Morris = B8 V ;
HD 175362: S_Q = B3, de Vaucouleurs = B8 IV .

For twenty-two stars, no MK types were given; S_Q types were computed, assuming the star to have no peculiarities and to belong to luminosity classes III–V.

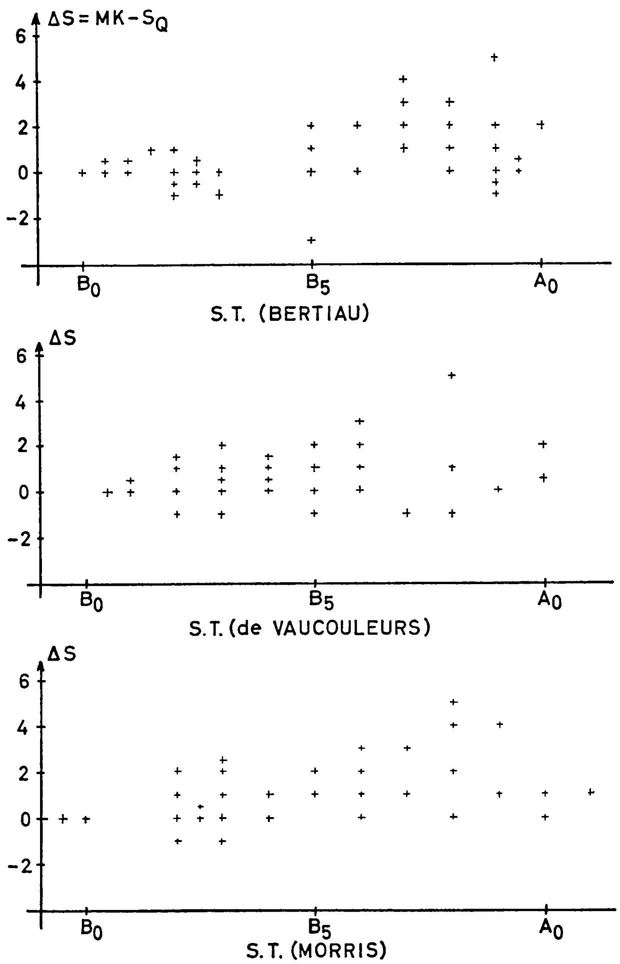


FIG. 3.—Differences between the S_Q spectral types and the MK classifications given by Bertiau, de Vaucouleurs, and Morris.

It should be noticed here that the determination of intrinsic colors and spectral types by the Q-method implies an assumption with regard to the value of R, since Q is given by

$$Q = (U - B) - \frac{E_{U-B}}{E_{B-V}} (B - V) , \tag{3}$$

where the ratio of the color excesses depends on the value of R. An analysis of the interstellar absorption curves obtained from observations and from theoretical considerations, for example, by van de Hulst (1949), shows that the ratio of the color excesses is larger by about 0.1 for a region where $R = 3.0$ than for another with $R = 6.0$. It will be shown in the next paragraph that in the Upper Scorpius region the value of R is most probably close to 6.0 instead of 3.0. This would cause a systematic error in the spectral types; but the change in Q due to the use in this region of the values corresponding to $R = 3.0$

TABLE 5

MEAN VALUES OF ΔS

Spectral Type	Bertiau		de Vaucouleurs		Morris	
	n	ΔS (subclass)	n	ΔS (subclass)	n	ΔS (subclass)
O9.5	....	....	....	....	1	0.0
B0	2	0.0	....	....	2	0.0
B0.5	2	0.2	1	0.0	....	....
B1	4	0.1	4	0.2	....	....
B1.5	1	1.0	....	....	....	....
B2	21	0.3	19	0.3	7	0.6
B2.5	4	0.0	....	....	2	0.2
B3	8	0.1	37	0.4	18	0.2
B4	....	....	11	0.5	8	0.8
B5	7	0.7	16	0.8	11	1.4
B6	3	1.3	11	1.2	9	1.9
B7	8	2.5	1	−1.0	6	1.7
B8	5	1.2	3	1.7	6	2.7
B9	13	0.6	1	0.0	2	2.5
B9.5	4	0.2	....	....	....	....
A0	1	2.0	4	0.9	2	0.5

is about $0.1(B - V)$ and far too small to explain the systematic differences in S_Q, which require, for example, an error in Q of the order of 0.11 to have $\Delta S = 2$ for B7.

a) Distribution of Interstellar Absorption

The fact that differential reddening was found suggested the possibility of studying the distribution of interstellar matter. Heavily darkened regions are important to detect, since a different value of R may be needed there, as was found by Sharpless (1952) in his study of the Orion aggregate. This would imply a change in the corrected absolute magnitudes. Figure 4 shows the distribution in the sky of all the stars observed. The "square" corresponds to the Upper Scorpius region, which includes the densest part of the association. Dots represent Blaauw's certain members, and crosses all other program stars. Figures 5–9 show the reddening distribution according to different ranges in distance moduli. In each of these drawings the size of the circle surrounding the star is larger for the nearer stars and the density of the shading corresponds to the amount of reddening. For stars with no stream parallaxes, distance moduli were estimated on the basis of photometric and spectroscopic data, using the luminosity calibration for the MK

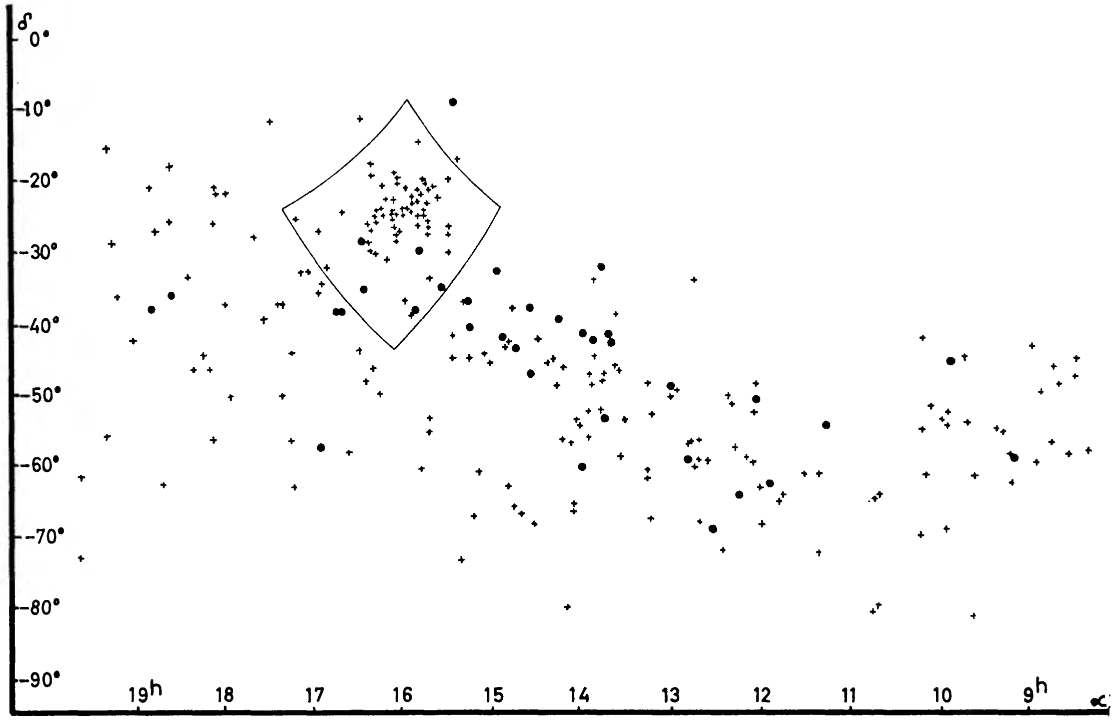


FIG. 4.—Distribution of the program stars in the sky. Blaauw's area 2 (Upper Scorpius region) is outlined.

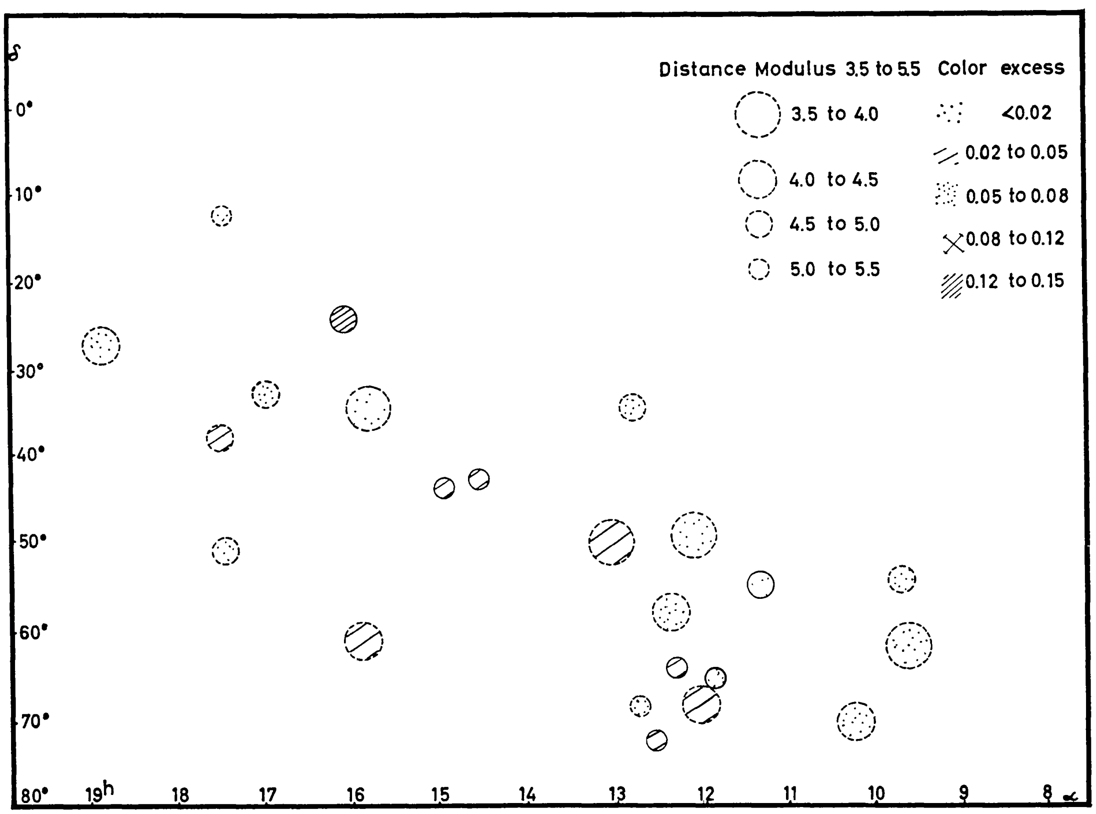


FIG. 5

FIGS. 5-9.—Distribution of interstellar reddening for the intervals of distance moduli given in the upper right corner of the diagrams. The meaning of the various shadings or color excesses are given in Figs. 5 and 6. Declinations are negative.

1968ApJS...15..459G

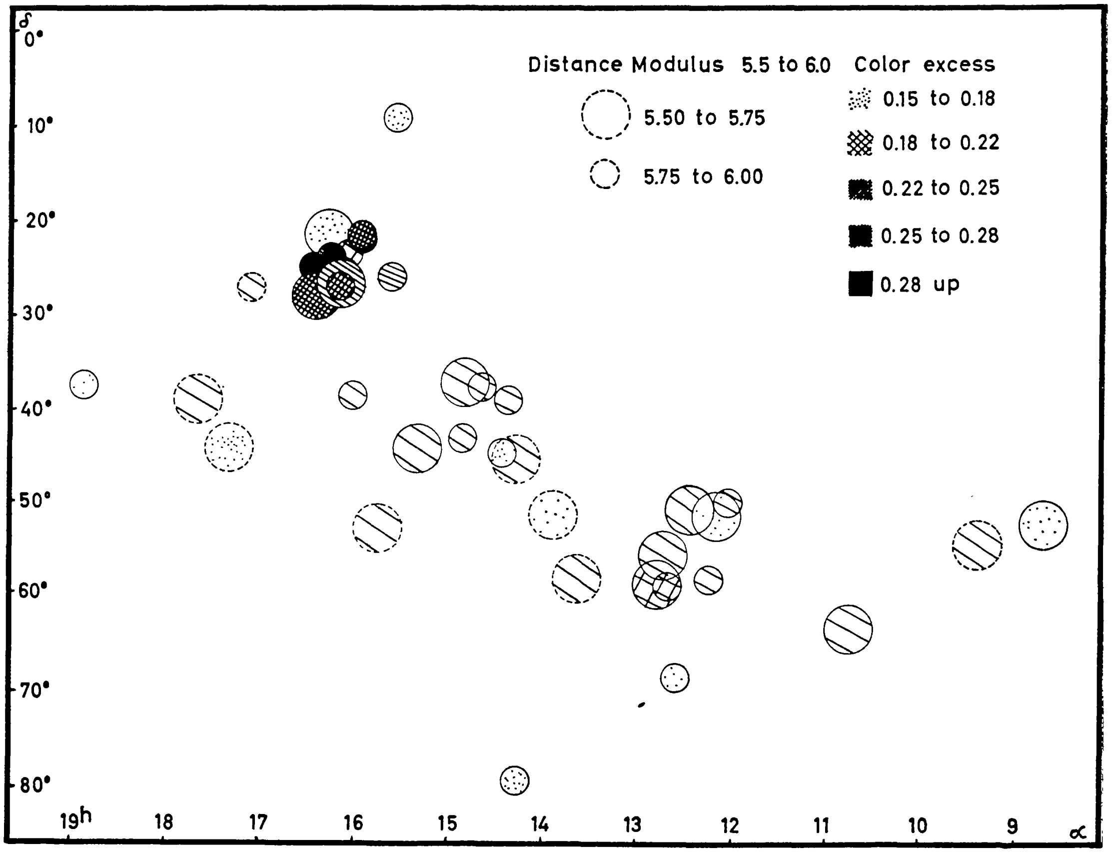


FIG. 6

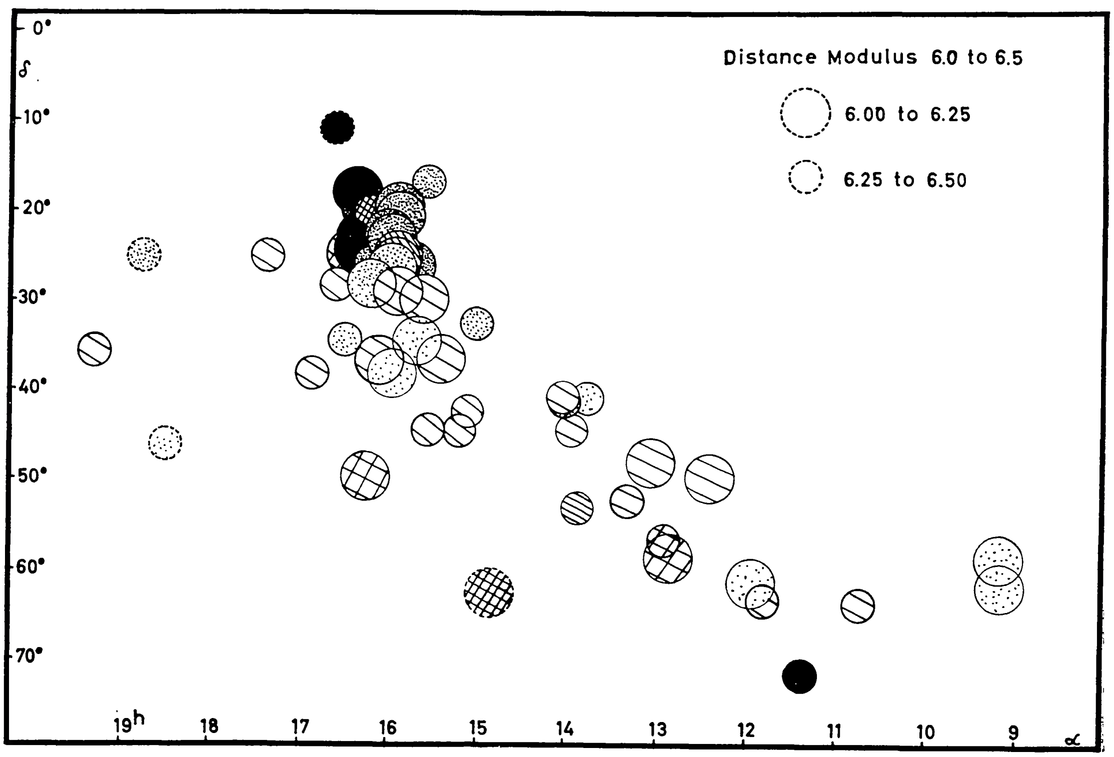
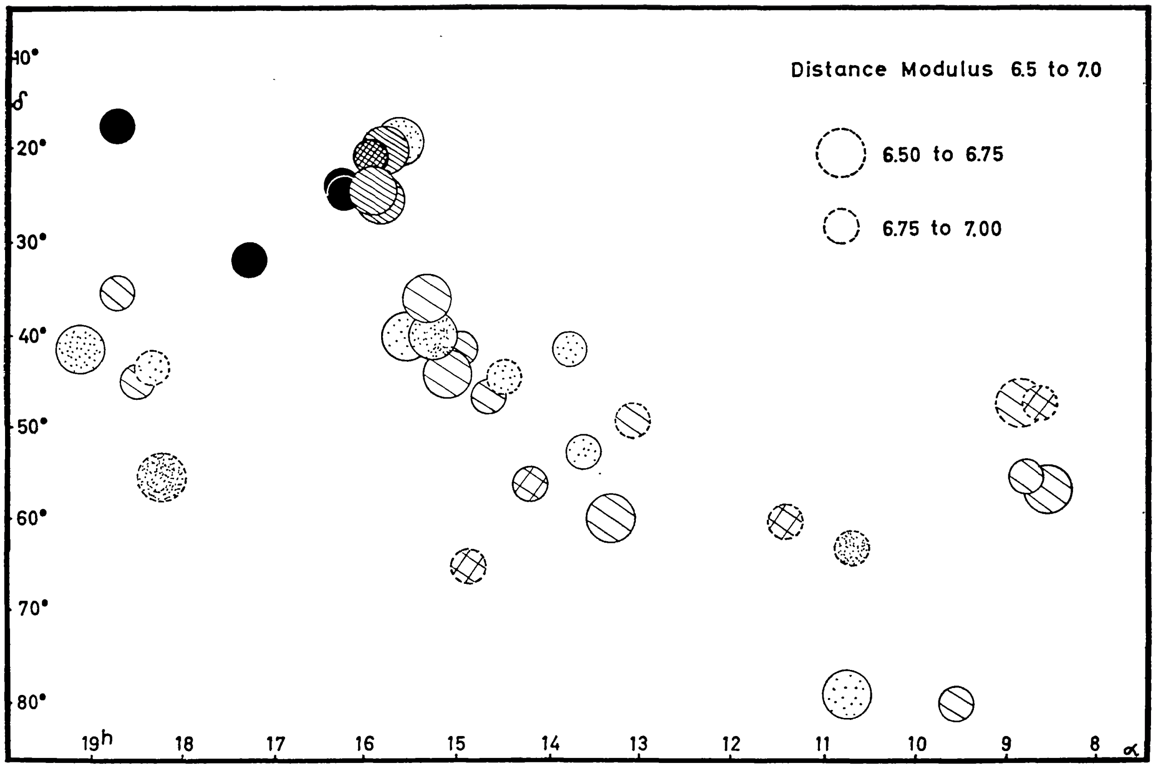
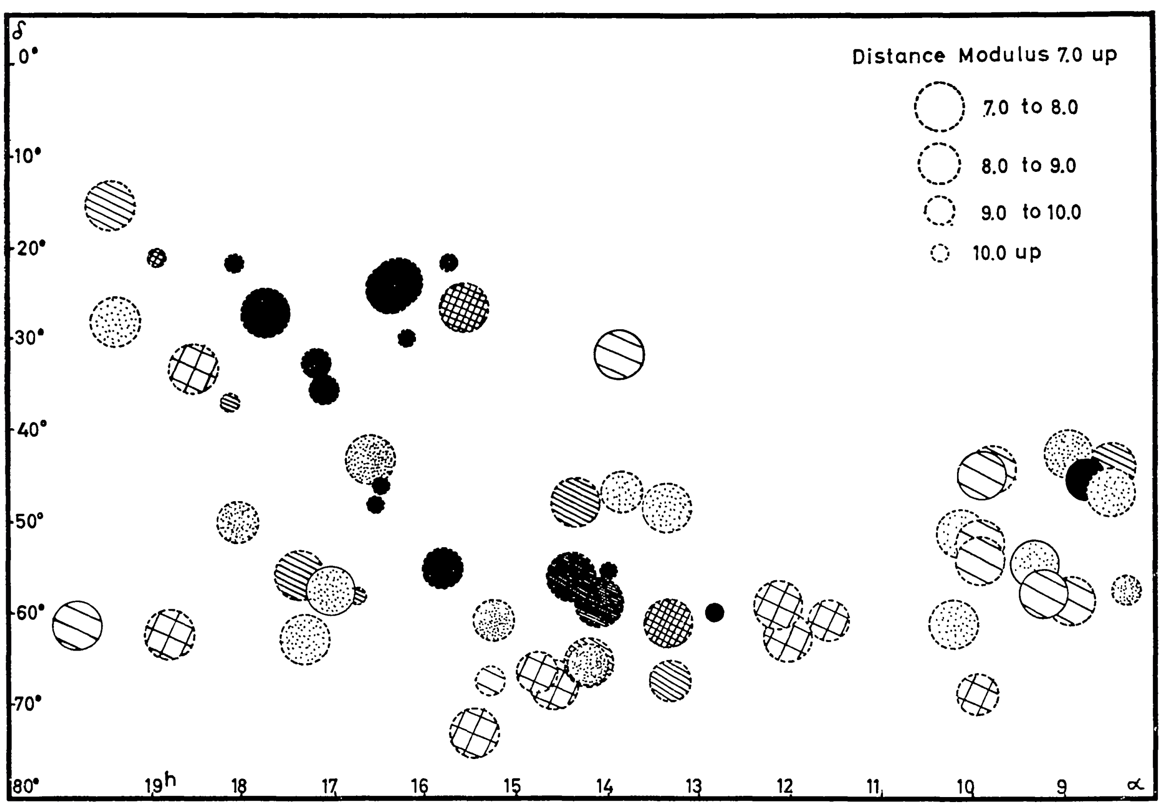


FIG. 7



Distance Modulus 6.5 to 7.0
6.50 to 6.75
6.75 to 7.00
10°
δ
20°
30°
40°
50°
60°
70°
80°
19h
18
17
16
15
14
13
12
11
10
9
8
α

Fig. 8



Distance Modulus 7.0 up
7.0 to 8.0
8.0 to 9.0
9.0 to 10.0
10.0 up
δ
0°
10°
20°
30°
40°
50°
60°
70°
80°
19h
18
17
16
15
14
13
12
11
10
9
α

Fig. 9

system, as given by Johnson and Iriarte (1958). Stars not considered members or probable members of the association are indicated by a dashed rim. Figure 5 contains mostly stars between us and the association, and Figure 9 includes mainly background stars.

Regarding the reddening distribution, Figures 6–8 show a common characteristic: the heavily reddened region in Upper Scorpius. The presence of a thicker cloud in this region, covering part of the constellations Ophiuchus and Scorpius, has been recognized since the end of the last century, when it was discovered photographically by Barnard. Khavtassi (1960) presents it as an aggregate of dark nebulosities and bright lanes, surrounding the stars α and σ Sco and ρ and ψ Oph. Our photometric results show also the presence of absorbing clouds in the region between 13^h and 15^h of right ascension and $-55°$ and $-60°$ declination, near the stars β Cen and v Cen. A faint nebulosity was detected surrounding the stars δ and π Sco.

To investigate the ratio of total to selective absorption, we followed the method given by Sharpless (1952). We used all the stars in the Upper Scorpius region which belong to

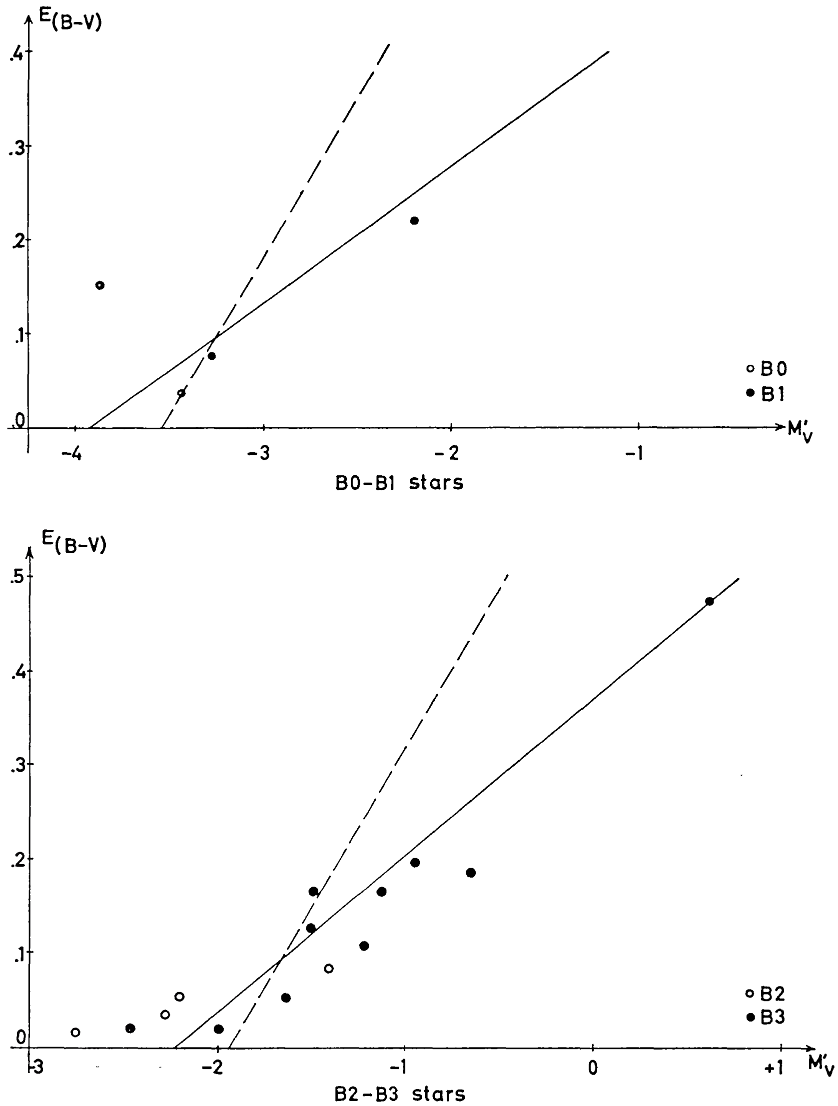


FIG. 10.—Plot for the determination of the ratio of total to selective absorption. M_v' = absolute magnitude uncorrected for absorption. The dashed lines correspond to R = 3.0; the continuous lines to R = 6.0.

luminosity class V and show no peculiarities in their spectra; they were divided into four groups according to the spectral types: B0–B1, B2–B3, B5–B7, and B8–B9. For the first two groups, absolute magnitudes uncorrected for absorption were plotted versus the color excess. For the other two groups, observed magnitudes were used since most of the stars in these two groups do not have accurately known distance moduli, though all of them are within the range accepted for the association; the results are given in Figures 10 and 11, where the dashed line corresponds to $R = 3.0$ and the solid one to $R = 6.0$. Apparently the value $R = 6.0$ fits the observations better.

The relation between the magnitudes and the color excesses given in Figures 10 and 11 is complicated by the real dispersion in the absolute magnitudes of the stars and, in the case of B5–B9 stars, by the dispersion in the observed magnitudes due to differences in distance moduli (range about 0.6 mag). All these considerations imply that in this region the value of R seems to be abnormally high, close to 6; but the exact value can only be determined by an extension of the photometric work to more than three colors, including infrared observations (Whitford 1948).

Outside this region, the reddening is not large enough to check the value of R.

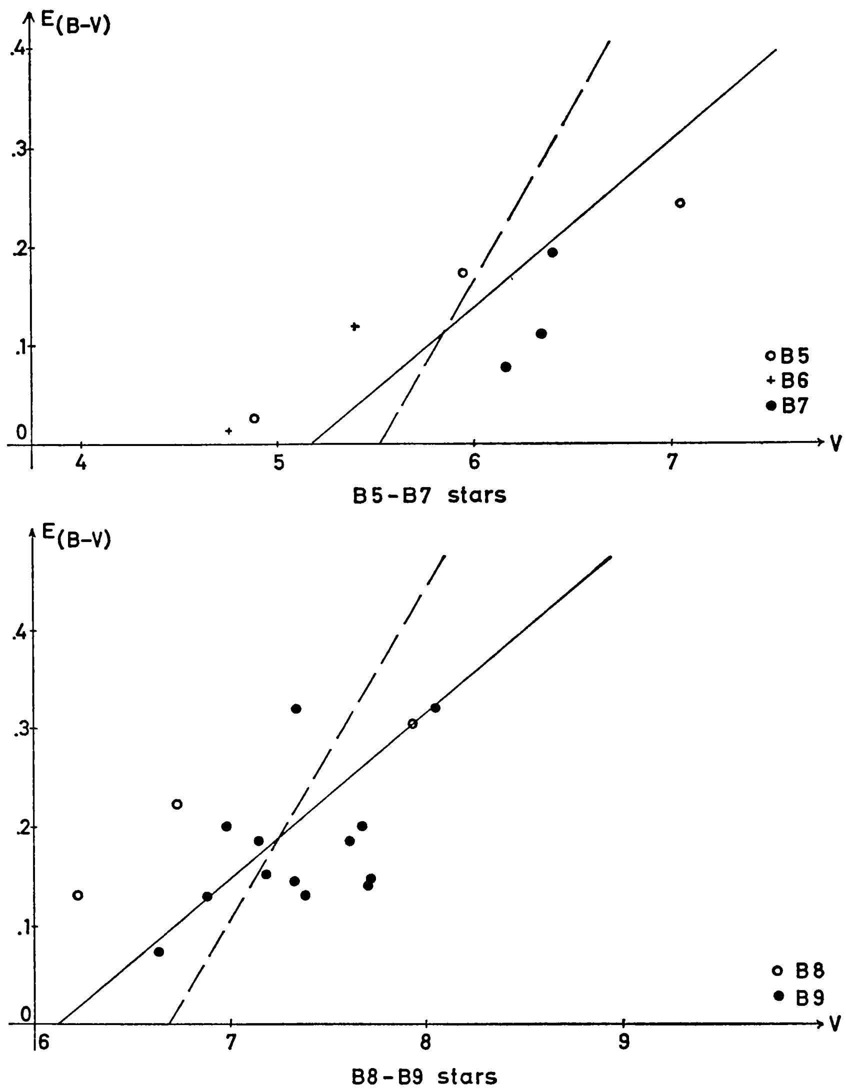


FIG. 11.—The same as Fig. 10 for later B-type stars. V = apparent magnitude uncorrected for absorption.

b) The Absolute Magnitudes

Using our magnitudes, corrected for interstellar absorption, and the parallaxes obtained by Bertiau (1958), we can determine the absolute magnitudes for the stars in common to both programs. The results are given in Table 6, which lists the HD number of the star, the distance modulus as given by Bertiau, the M_v values obtained from these moduli using first $R = 3.0$ for all stars and then $R = 6.0$ for stars in the Upper Scorpius region, and, finally, a set of M_v values obtained in the next paragraph from β measurements. Figures 12 and 13 give the color–absolute-magnitude diagrams for stars of luminosity classes IV and V; dots correspond to stars in the Upper Scorpius region and crosses to all other stars; the value $R = 3.0$ was used for all stars.

The scatter present in these diagrams is due to several causes. The most important are (*a*) the errors due to uncertainty in the parallaxes; (*b*) the presence of double and multiple stars; (*c*) the errors introduced when we apply the reddening and absorption corrections.

TABLE 6

ABSOLUTE MAGNITUDES

HD	m_0-M	M_v	$M_v(\beta)$	HD	m_0-M	M_v		$M_v(\beta)$
		$R=3.0$				$R=3.0$	$R=6.0$	
103079...	5.48	−0.76	−0.90	132955...	6.30	−1.04	....	−0.90
103884...	6.15	−0.63	−1.43	133937...	6.46	−0.68	....	−0.72
105382...	5.90	−1.52	−1.85	133955...	6.59	−2.61	....	−1.70
105435...	5.90	−3.65	....	136298...	6.59	−3.62	....	−3.23
105937...	5.60	−1.70	−1.07	136664...	6.59	−2.17	....	−1.28
106490...	5.81	−3.09	−3.26	137432...	6.04	−0.69	....	−1.15
106983...	5.48	−1.49	−1.80	138485...	6.34	−1.05	−1.29	−2.30
108257...	5.65	−0.97	−1.70	138690...	6.59	−3.83	....	−3.00
108483...	6.11	−2.26	−2.41	138764...	5.97	−0.96	−1.11	−0.44
109026...	5.38	−1.59	−1.38	138769...	6.38	−1.91	....	−1.65
109668...	5.84	−3.20	−2.38	139365...	6.15	−2.54	−2.60	−1.73
110956...	5.54	−0.96	−1.15	140008...	6.11	−1.40	−1.44	−0.78
111123...	5.68	−4.50	−4.08	141637...	6.15	−2.00	−2.50	−2.62
112078...	6.18	−1.59	−1.65	142096...	6.15	−1.62	−2.11	−1.00
112091...	6.30	−1.62	....	142114...	6.11	−1.89	−2.27	−1.80
112092...	6.30	−2.31	−2.02	142165...	6.07	−1.03	−1.39	−0.80
113703...	6.00	−1.39	−1.80	142184...	6.07	−1.21	−1.75	−2.37
113791...	6.88	−2.67	−2.18	142378...	6.22	−0.78	−1.30	−1.30
115823...	6.30	−0.91	−0.75	142669...	6.18	−2.40	−2.51	−2.60
116087...	6.51	−2.03	−1.24	143018...	6.15	−3.49	−3.71	−3.35
118716...	6.83	−4.52	−3.43	143118...	6.18	−2.81	−2.86	−3.25
120307...	6.26	−2.89	−2.75	143275...	6.18	−4.33	−4.78	−4.03
120324...	6.83	−3.45	....	143699...	5.84	−1.02	−1.09	−1.51
120908...	6.30	−0.86	−1.28	144294...	6.22	−2.06	−2.12	−1.94
120955...	7.54	−2.86	−1.65	144470...	6.15	−2.87	−3.52	−3.20
121743...	6.34	−2.56	−1.96	145482...	6.22	−1.80	−1.96	−2.42
121790...	6.30	−2.50	−2.50	145502...	6.11	−2.91	−3.71	−1.75
122980...	6.34	−2.05	−2.53	147084...	6.18	−3.66	−5.70	....
125823...	5.81	−1.46	−2.57	147888...	6.11	−0.79	−2.20	....
127972...	5.40	−3.12	....	148184...	6.11	−3.13	−4.57	....
129056...	6.78	−4.53	−3.88	148605...	6.18	−1.67	−1.92	−2.25
129116...	5.84	−1.92	−1.72	148703...	6.46	−2.38	−2.54	−2.43
130807...	5.94	−1.69	−1.56	149438...	6.26	−3.54	−3.65	−3.70
132058...	5.18	−2.54	−3.50	151890...	6.26	−3.34	....	−3.12
132200...	6.78	−3.70	−2.98	151985...	6.26	−2.77	....	−3.26
				157056...	6.26	−3.09	−3.19	−3.05

On the average, for the stars included in the graph, the internal probable error of the distance modulus as given in Bertiau's catalogue is ± 0.14 mag. The error in the interstellar reddening affects the graph not only in the horizontal sense but also in the vertical one, since it affects both the intrinsic color of the star and its magnitude; we will assume, in agreement with the analysis made by Hardie and Crawford (1961), that the magnitudes have a probable error due to reddening uncertainties equal to about ± 0.07. Then the total probable error (due to distance and reddening uncertainties) for the ab-

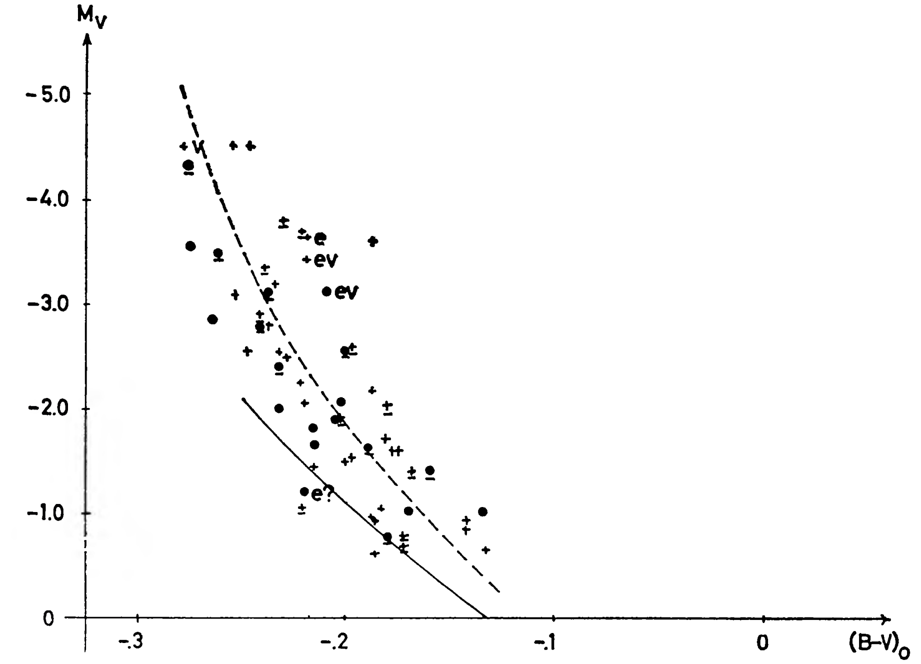


FIG. 12.—Color–absolute-magnitude diagram for $(B - V)_0$ for stars with known distance modulus. Dots correspond to stars in the Upper Scorpius region. $R = 3.0$. Bars denote double stars; e = emission; v = variable.

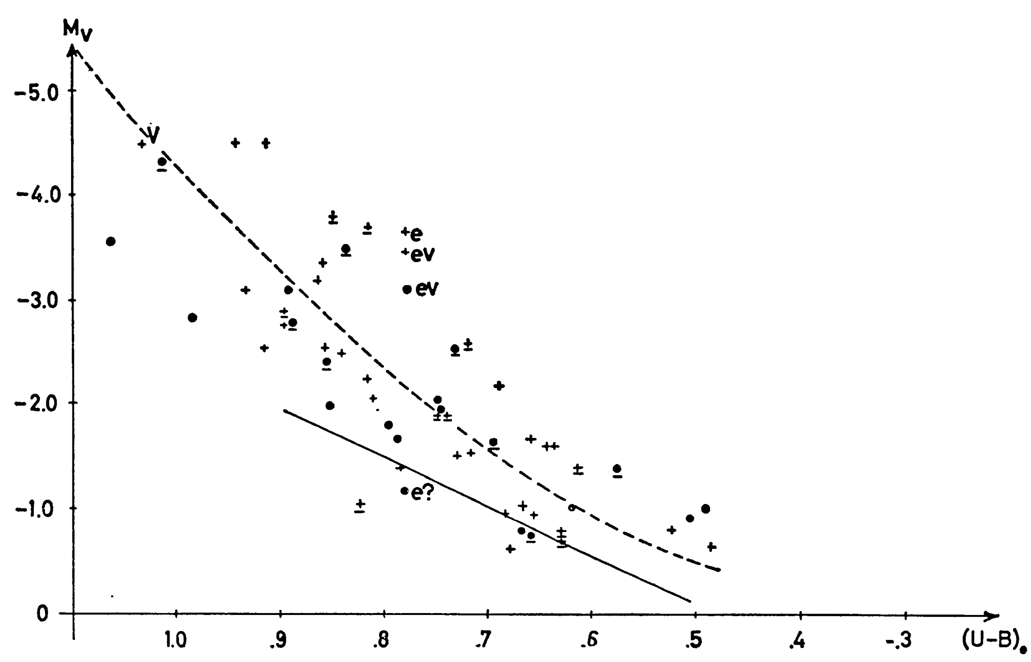


FIG. 13.—The same as Fig. 12 for $(U - B)_0$

solute magnitudes given in Table 6 will be ± 0.16 mag. The observational errors in the apparent magnitudes are negligible in comparison with these effects. On the other hand, we can use the curves in Figures 12 and 13 to obtain absolute magnitudes as functions of the intrinsic colors; the results will have a probable error which can be determined from the standard deviation corresponding to each curve. This deviation turns out to be ± 0.40 mag for the $(B - V)_0$ curve and ± 0.42 mag for the $(U - B)_0$ curve.

We have also drawn in both figures the zero-age main sequence taken from Johnson and Iriarte (1958). The relative position of these sequences and our own is such that it shows evolutionary effects. It is not possible to estimate the termination point of the $(B - V)_0$ unevolved main sequence for the association; but, in any event, the comparison of our diagram with those given by Sandage (1957) and Johnson (1960) suggests an age

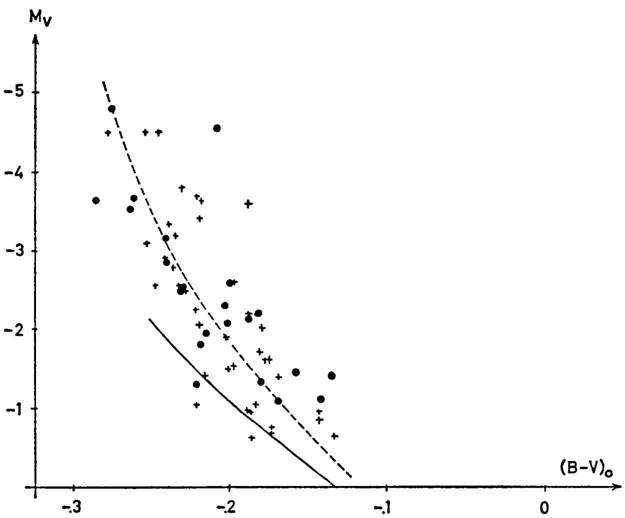


FIG. 14

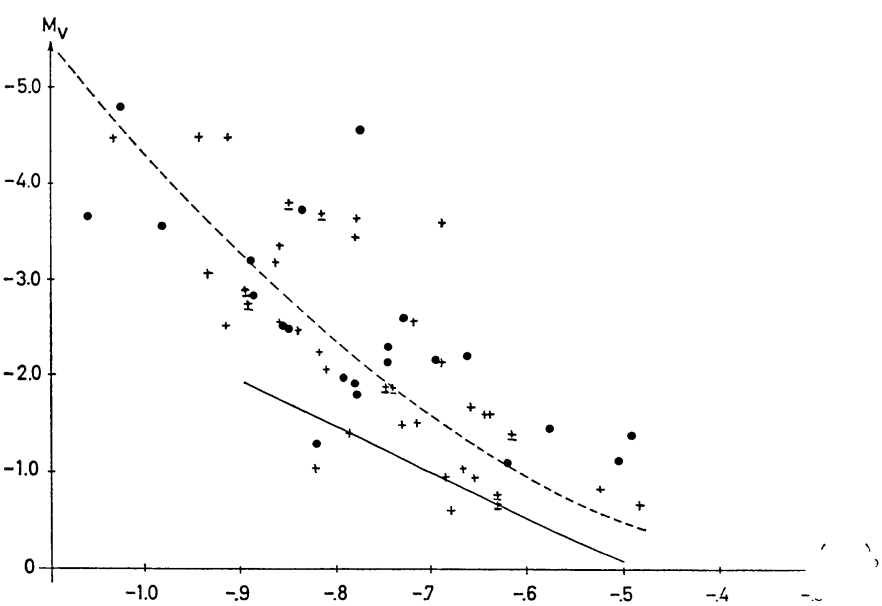


FIG. 15

FIGS. 14 AND 15.—The same as Figs. 12 and 13 but with $R = 6.0$ for stars in the Upper Scorpius region.

which is closer to Blaauw's value, 72×10^6 years (1952), than to that obtained by Bertiau, 20×10^6 years (1958).

Blaauw (1959) suggested that the stars in the Upper Scorpius region are intrinsically less luminous than those in the less dense regions of the association; this effect would be due to a difference in age and, consequently, in evolution, and would imply a more recent origin for the stars in the Upper Scorpius region, surrounded by nebulosities. Our plots show a small systematic difference between both groups of stars: the dots lie, in the mean, below the main sequence we determined; this would confirm Blaauw's suggestion. On the other hand, Figures 14 and 15 give the same plots when the computation of ab-

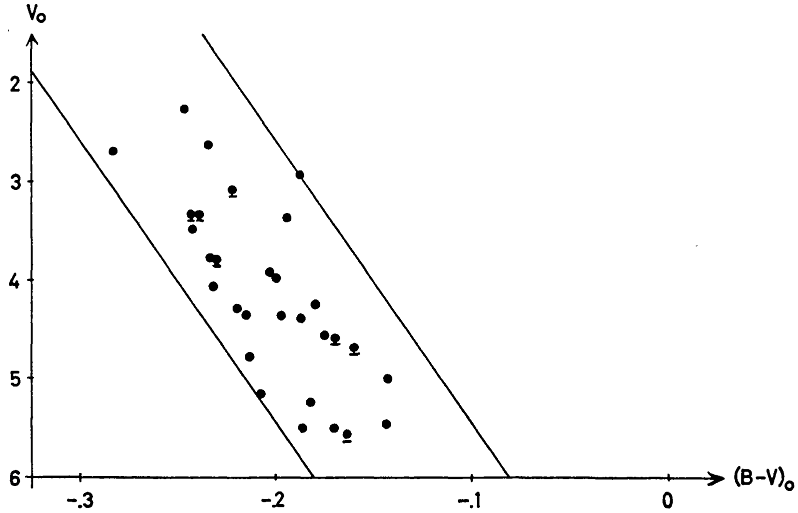


FIG. 16.—Color-apparent-magnitude diagram for $(B - V)_0$ for Blaauw's certain members

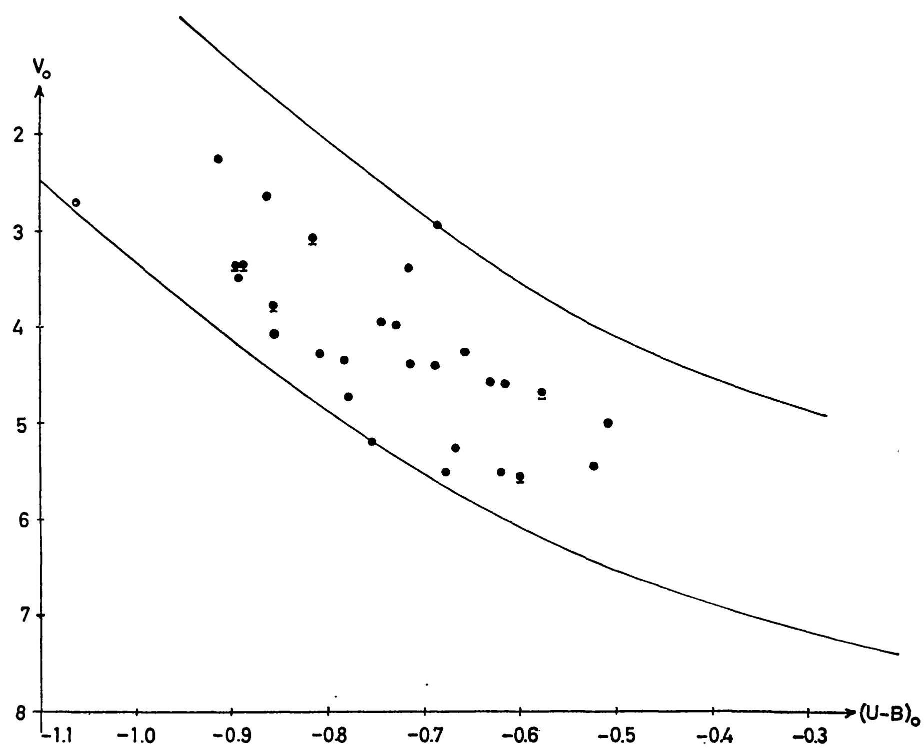


FIG. 17.—The same as Fig. 16 for $(U - B)_0$

sorption for the stars in the Upper Scorpius region is performed with the value $R = 6.0$; we see that in this case the systematic effect already mentioned practically disappears, as these stars come closer to the main sequence defined by the remaining members of the association.

c) Color–Apparent-Magnitude Diagrams for All Stars Observed

Figures 16 and 17 show the color–apparent-magnitude diagrams for the stars considered by Blaauw to be certain members of the association. We cannot expect to find a narrow main sequence in this case; there are several sources of scatter, which include not only the presence of double and multiple stars, the errors due to reddening uncertainties, and the observational errors, but also the following: (*a*) the differences in distance moduli which, according to Bertiau's values, range from 5.48 to 7.54 mag (note that the mean distance happens to be virtually independent of the position in the sky although the group stretches over a wide range in longitude); this implies a vertical scatter of 2 mag; and (*b*) the differences in interstellar absorption due to the fact that the stars are spread over a large region in the sky, with different amounts of absorbing material.

We will assume, then, that the stars belonging to the association occupy a region in the color–apparent-magnitude diagrams, defined by the limits we have drawn in Figures 16 and 17. The use for the Upper Scorpius region of $R = 6.0$ instead of $R = 3.0$ does not

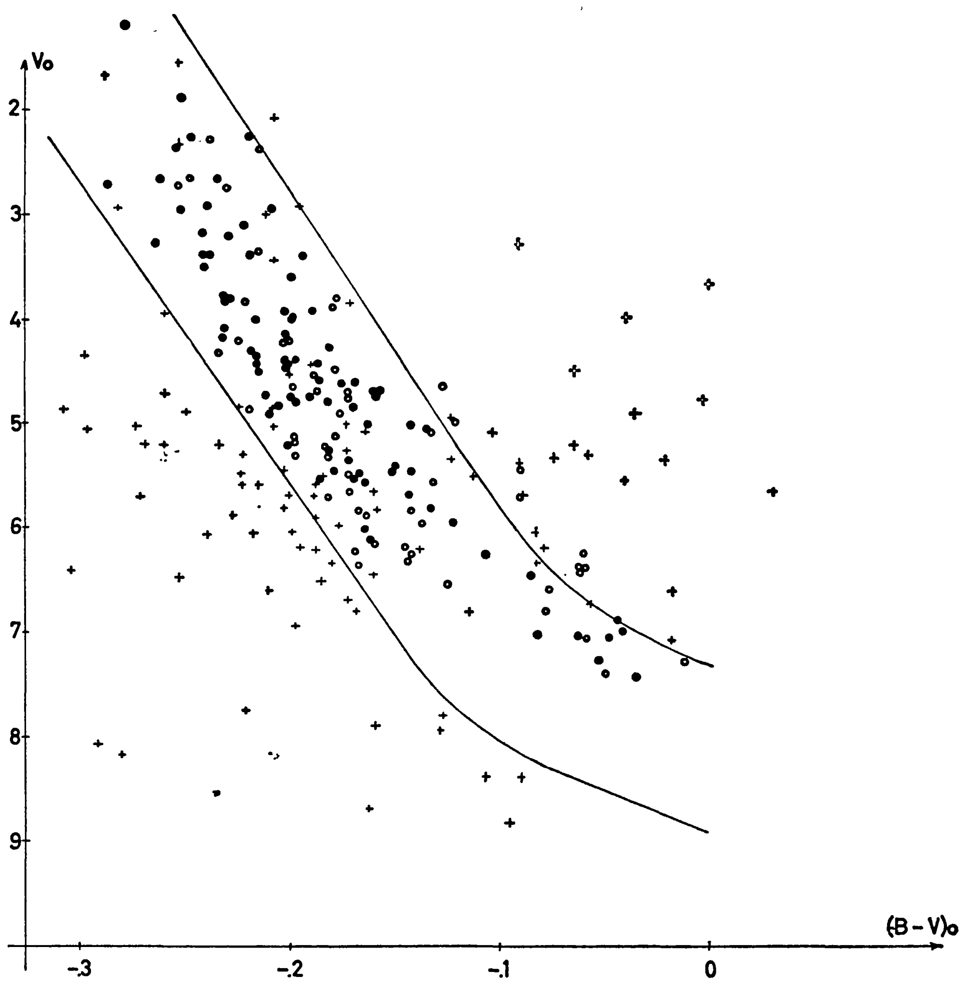


FIG. 18.—Color–apparent-magnitude diagram for $(B - V)_0$ for all observed stars. For explanation of symbols see the text.

change these limits. Figures 18 and 19 show the color–apparent-magnitude diagrams for all stars observed belonging to luminosity classes III, IV, or V. The limits are the same as in the preceding plots, extrapolated so as to contain the fainter and later-type stars, on the basis of the standard main sequence given by Johnson and Iriarte (1958) for $(B - V)_0$, and in agreement with the solution given by Hardie and Crawford (1961) for $(U - B)_0$. The position of the individual stars in these diagrams gives a criterion to study their membership. In each case the photometric criterion may be reinforced by the available data about proper motions and radial velocities. The proper motions were taken from Bertiau (1958) when available; in the other cases they were taken directly from the N30 catalogue (Morgan 1952) and compared with the proper motions given in

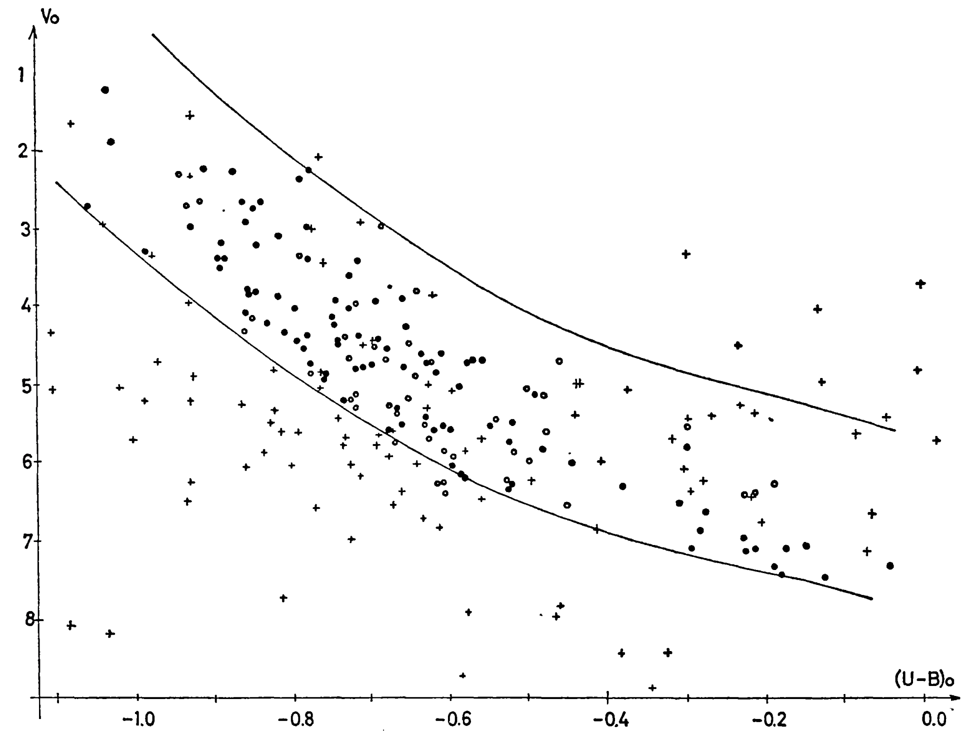


FIG. 19.—The same as Fig. 18 for $(U - B)_0$

this same catalogue for Blaauw's certain members. The radial velocities were taken from Wilson (1953); Feast, Thackeray, and Wesselink (1954, 1957); Buscombe and Morris (1960, 1962); Buscombe (1962); and van Hoof, Bertiau, and Deurinck (1963). Some supplementary data were kindly sent from Mount Stromlo Observatory.

The proper motions were analyzed by plotting them and comparing their size and direction with those of Blaauw's certain members. For radial velocities, the mean for each of Blaauw's areas was calculated for certain members, and the standard deviation σ with respect to this mean was computed for each star in the area. A fourth criterion of membership is the determination of the distance modulus on the basis of the photometric data and the spectral types. All these criteria are summarized in the last four columns in Table 11 (see below), where the letters a, b, and c were assigned to each star according to Table 7, which gives the limits set for each criterion.

In agreement with the preceding criteria, the stars in Figures 18 and 19 were drawn as dots (all a's), open circles (a's and b's), or crosses (some c's).

These plots were drawn using the value $R = 3.0$ for the Upper Scorpius region. The use of $R = 6.0$ produces only minor changes, without altering the general results.

IV. THE Hβ PHOTOMETRY

Hβ observations were made for all stars brighter than magnitude 6.5 and having no c in the membership criteria given in Table 11 (see below); the mean number of observation nights was ten for the standard stars and three for the program stars. Before forming the mean β in the natural system for each star, night-to-night corrections had to be applied. These corrections turned out to be temperature dependent, as shown in Figure 20, with a temperature coefficient equal to $+0.001$ per degree Fahrenheit. After applying these corrections, the mean of the probable errors is ± 0.003 for the standard stars and ± 0.004 for the program stars. These values were transformed to the new (1964) Crawford standard system for B stars; the relation used was (Fig. 21)

$$\beta = -0.166 + 1.071\beta_M . \tag{4}$$

The probable error of the transformation for one star is ± 0.0047. Table 8 lists the standard stars used, their MK classification according to Crawford, the β values as given by Crawford (β_c) and those obtained by us.

The results for the Scorpio-Centaurus stars are given in Table 12 (see below). A comparison was made between our results and those given by Hardie and Crawford

TABLE 7

MEMBERSHIP CRITERIA

	a	*b*	*c*
Photometric......	Inside both diagrams	Inside one of the diagrams and outside the other; or outside both of them but near the boundaries	Outside both diagrams
μ...............	Nearly parallel and about the same size as for certain members	Size and direction more or less equal to certain members	Not parallel or very different in size as compared to certain members
V_R..............	$\lvert \overline{V}_R - V_R \rvert \leq \sigma$	$\sigma < \lvert \overline{V}_R - V_R \rvert \leq 2\sigma$	$\lvert \overline{V}_R - V_R \rvert > 2\sigma$
$m_0 - M$..........	$5.48 \leq m_0 - M \leq 7.54$	$5.00 \leq m_0 - M < 5.48$ $7.54 < m_0 - M \leq 8.00$	$m_0 - M < 5.00$ $m_0 - M > 8.00$

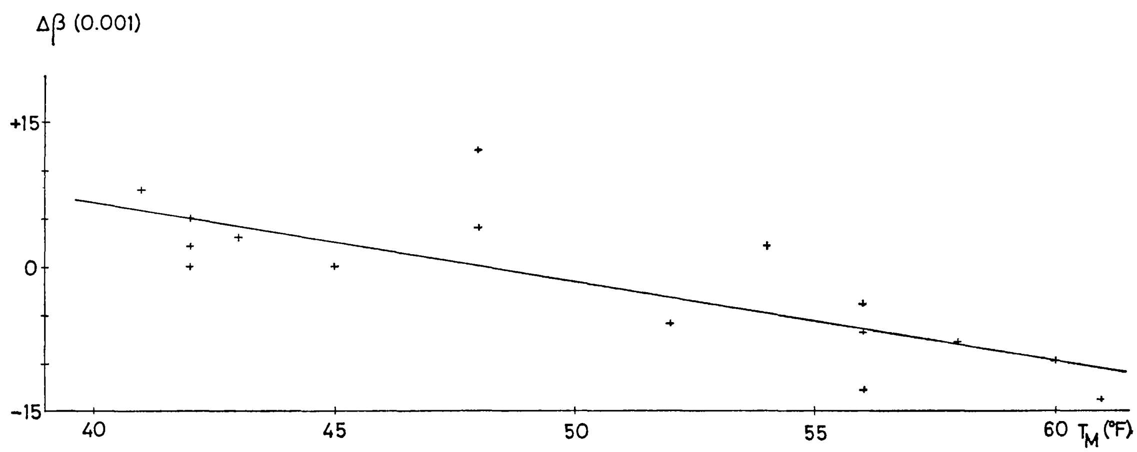


FIG. 20.—Temperature dependence of β

(1961) for the Scorpio-Centaurus association. Although their values are given in a slightly different system, the agreement is good, the largest difference being 0.022. This same maximum difference was found between our results and those obtained by Graham (1964), with the exception of two stars, HD 113791 and HD 125823, for which the differences in the sense Moreno-Graham are +0.06 and +0.04, respectively.

Figure 22 gives the relation between β and $(U - B)_0$ for all the stars observed. Dots correspond to stars which have four a's in Table 11 (see below); crosses represent stars with only a's but for which some of the four criteria are missing. Open circles correspond

TABLE 8

β STANDARDS

HD	Name	MK	β_c	β
87901.........	α Leo	B7 V	2.725	2.734
91316.........	ρ Leo	B1 Ib	2.555	2.553
130109.........	109 Vir	A0 V	2.847	2.856
135742.........	β Lib	B8 V	2.710	2.709
143018.........	π Sco	B1 V	2.615	2.618
143275.........	δ Sco	B0 V	2.602	2.598
148605.........	22 Sco	B2 V	2.665	2.658
161868.........	γ Oph	A0 V	2.907	2.909
164353.........	67 Oph	B5 Ib	2.589	2.582
177724.........	ζ Aql	A0 V	2.878	2.869
184915.........	κ Aql	B0.5 III	2.563	2.575
184930.........	ι Aql	B5 III	2.711	2.705
196867.........	α Del	B9 V	2.802	2.800
214923.........	ζ Peg	B8 V	2.773	2.763

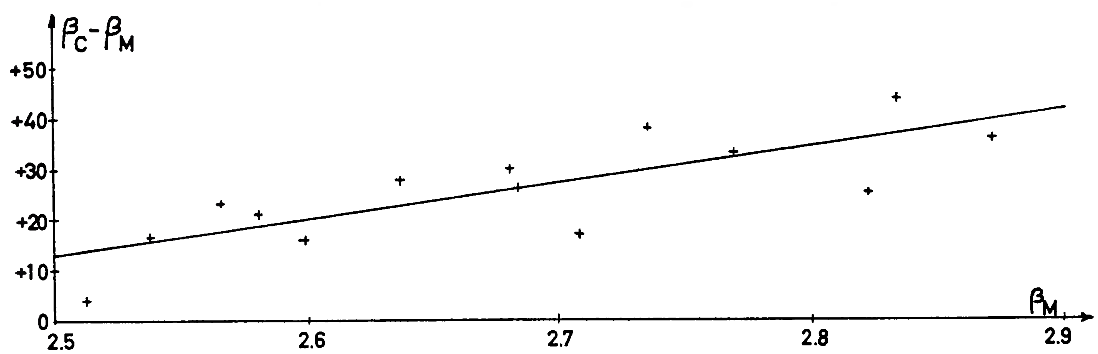


FIG. 21.—β_M transformation to Crawford system

to stars with a's and b's. As shown by Crawford (1958), this diagram allows us to distinguish stars of various luminosities and evolutionary ages; consequently, it will give us new information about the membership of the stars studied. In Figure 22 the dots define a rather narrow strip, with the exception of four emission stars, which lie high above the mean relation. Only three crosses deviate from this strip: they correspond to the stars HD 80781, 156352, and 170523, for which μ data are missing; these stars are probably non-members. Most of the stars with a's and b's also fall inside the strips defined by the dots; this would confirm their probable membership. The stars which deviate from the mean relation are:

HD 72350: b in V_R and distance modulus; considered a non-member;
HD 75311: emission star; probably a member and shifted up due to emission;

HD 81188: near the mean relation; *b* in μ and modulus; probably a non-member;
HD 86440: *b* in photometric criterion, μ, and modulus; luminosity class II; non-member;
HD 88206: *b* in μ and V_R; considered a non-member;
HD 110335: *b* in photometric criterion; no data about μ; considered a non-member;
HD 126341: near the mean relation; *b* in V_R; probably a member;
HD 127972: *b* in V_R and modulus; considered a non-member;
HD 161756: near the mean relation; *b* in μ and modulus; no information about V_R; probably a non-member.

As outlined above, it is possible to distinguish stars of different ages by means of the β, $(U - B)_0$ diagram. Thus we can use our β measurements to study the possibility of

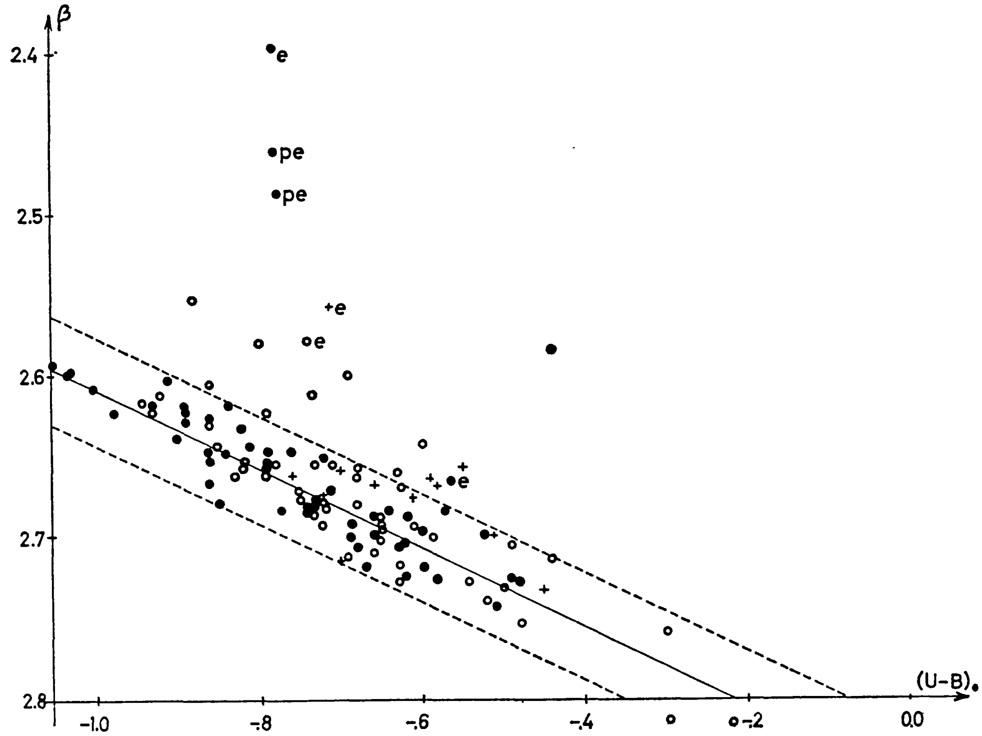


FIG. 22.—β against $(U - B)_0$ for all stars observed. For explanation of symbols see the text

the existence of different evolutionary sequences in the Scorpio-Centaurus association. Figure 23 shows a plot of β versus $(U - B)_0$ for association members in the Upper Scorpius region. The straight line in the diagram represents the average relation for stars outside this region. Evidently the stars in the Upper Scorpius region define a slightly different sequence. This fact can be explained in two ways: (1) According to Crawford (1958) these stars are younger than those of the remainder of the association. This interpretation agrees with the conclusion arrived at by Blaauw (1959). (2) The $(U - B)_0$ colors used for the graph in Figure 23 were obtained by applying the Q method. The latter assumes a certain ratio between the color excesses E_{B-V} and E_{U-B}. If a different reddening law applies to the Upper Scorpius region as is indicated by the different value of $R = A_V/E_{B-V}$ which was found, then it may also be necessary to use a different value for the ratio of the color excesses. To remove entirely the excess of $(U - B)_0$ in the graph in Figure 23 it would be necessary to assume a value of this ratio equal to about 0.2. This value seems rather improbable.

Of course it is also possible to explain the systematic difference in the β, $(U - B)_0$ relation for a certain group of the Scorpio-Centaurus association members by a combination of both effects, that is, a slightly different reddening law applying to a group of stars of slightly different age.

Figures 24 and 25 give the M_v, β diagrams for all stars accepted as members and with distance moduli given by Bertiau. The M_v values are those given in Table 6, using $R = 3.0$ for all stars in Figure 24 and $R = 6.0$ for the Upper Scorpius region in Figure 25; the

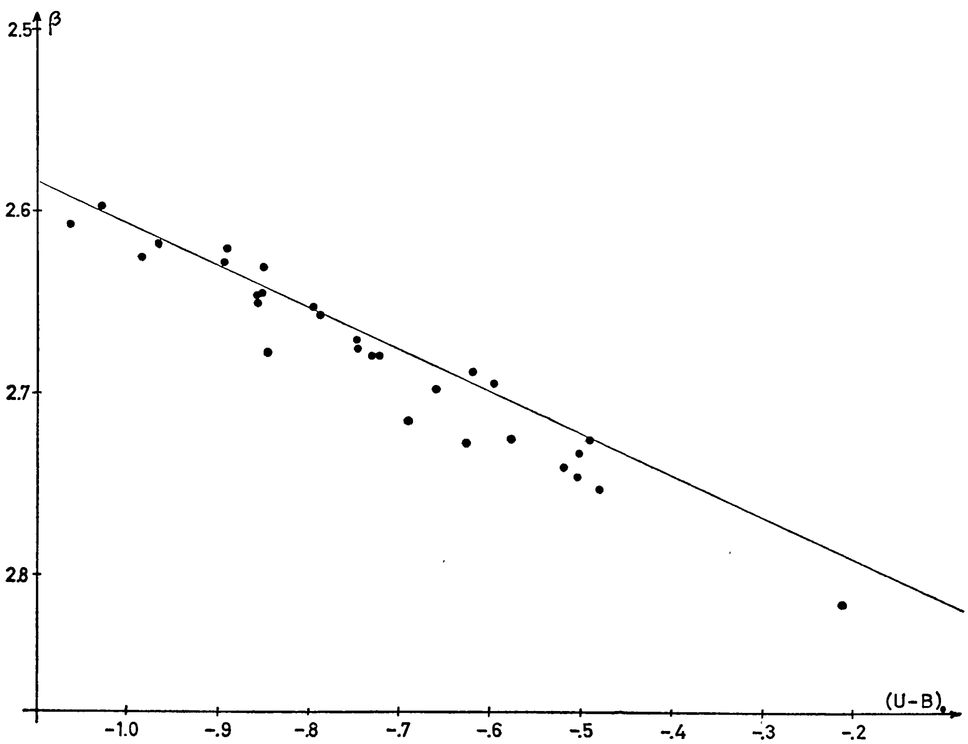


FIG. 23.—β versus $(U - B)_0$ for stars in the Upper Scorpius region. The straight line represents the average relation for stars outside this region.

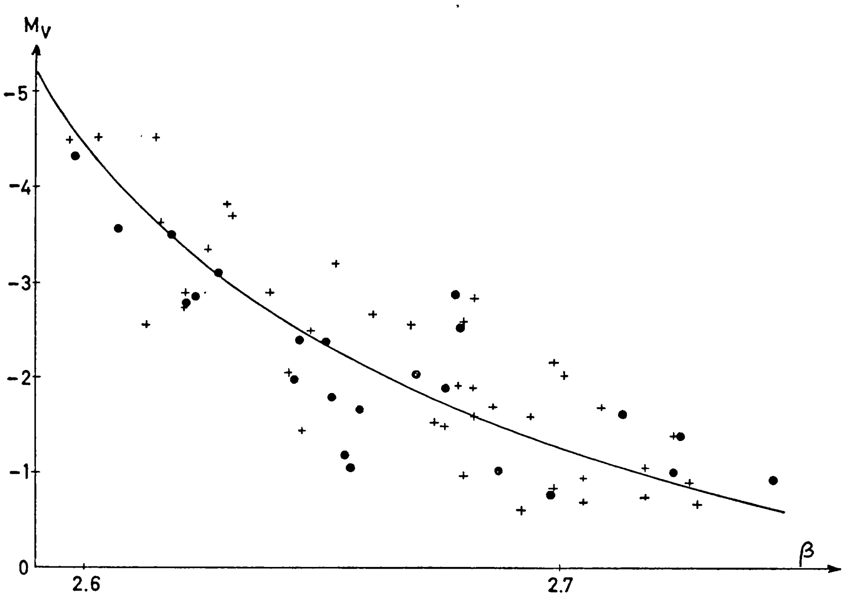


FIG. 24.—M_v versus β for stars with known distance moduli, using $R = 3.0$ for all stars

stars in this region are represented by dots. The calibration curves are the same in both diagrams; the use of $R = 6.0$ does not imply a significant change. The scatter in these two diagrams is large and corresponds to a standard deviation in M_v equal to ± 0.58 mag for the curve drawn using $R = 3.0$. The causes of these scatters are the same as already mentioned for Figures 12 and 13; besides, the probable error of the β values (± 0.004 in the mean) corresponds to an uncertainty of about ± 0.25 mag for the brighter stars and ± 0.05 for the fainter ones. An attempt was made to detect a possible dependence of the M_v, β relation on $(U - B)_0$ or spectral types; such a dependence was not found; if it exists, it is negligible in comparison with the scatter shown in Figures 24 and 25.

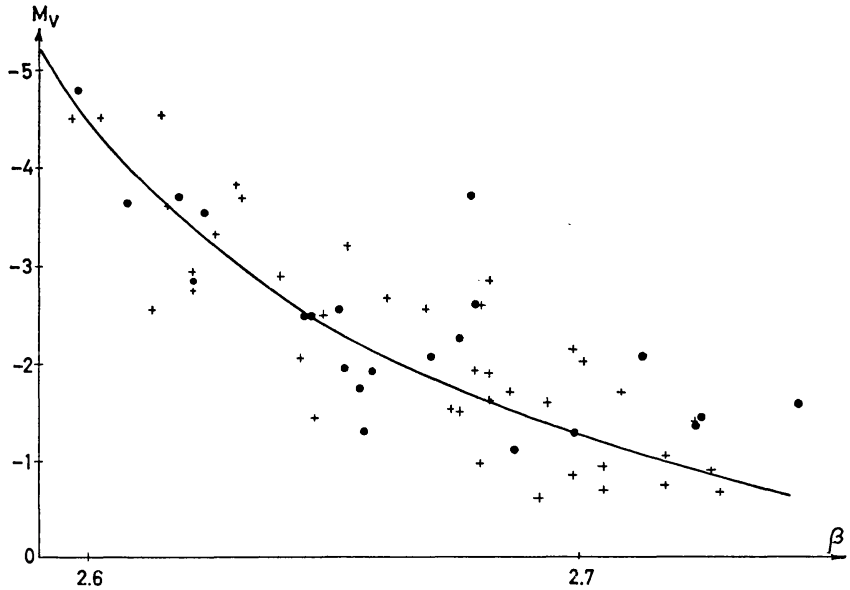


FIG. 25.—The same as Fig. 24, using $R = 6.0$ for stars in the Upper Scorpius region

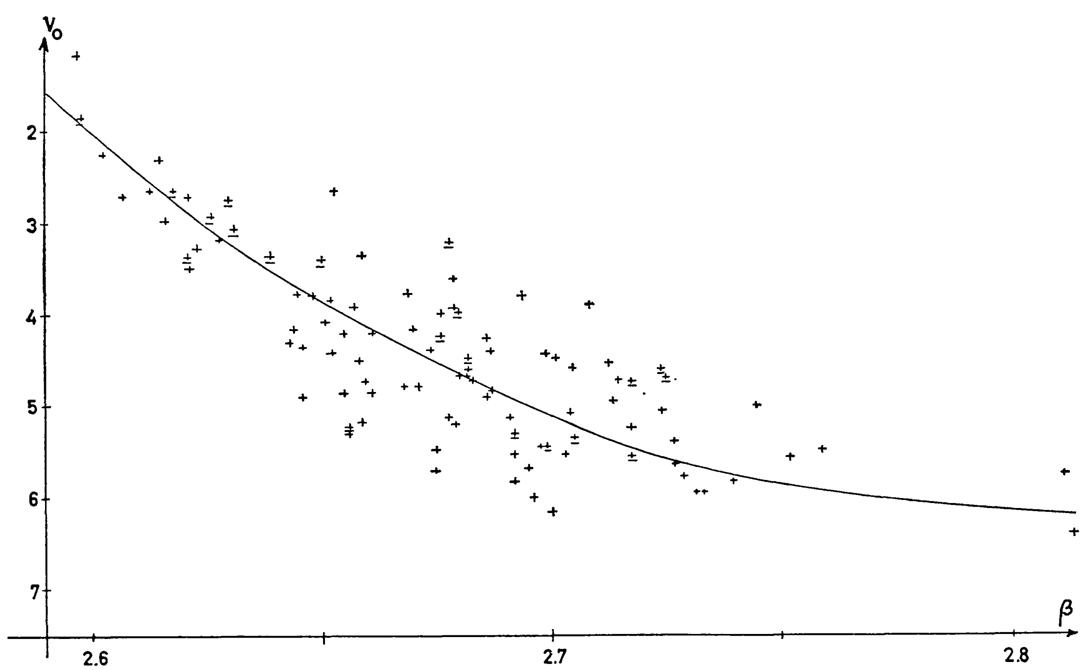


FIG. 26.—V_0 versus β for all program stars which can be considered as members

Figure 26 gives a calibration of V_0 as a function of β. All stars retained as members and having no peculiarities were used to draw the curve. Bars denote double stars; no attempt has been made to obtain a different calibration when they are not included. The scatter corresponds to a standard deviation in the magnitudes of ± 0.60 and is partly due to the real scatter in distance.

Table 9 summarizes the results of the calibrations obtained from Figures 24 and 26, using for the last one a mean distance modulus of 6.18 mag, which corresponds to all stars used. The last two columns give Hardie and Crawford's calibration and the value of the slope $dM_v/d\beta$ for different parts of the curve.

Since the agreement with Hardie and Crawford's calibration is good—except for the fainter stars, for which we have very few observations—absolute magnitudes and distance moduli were determined using their calibration and our β values. The results are given in Table 12, which lists the HD number of the star, the distance moduli obtained from the β measurements and those given by Bertiau when available. The external probable error between both sets of values is, for one star, ± 0.40 mag.

TABLE 9

CALIBRATION OF M_v AS A FUNCTION OF β

M_v	β			$dM_v/d\beta$
	Bertiau's Moduli	Mean Modulus	Hardie and Crawford	
−4.5	2.600	2.593	....	48
−4.0	2.609	2.604	....	44
−3.5	2.618	2.616	2.613	40
−3.0	2.631	2.630	2.630	36
−2.5	2.645	2.644	2.648	32
−2.0	2.665	2.663	2.668	27
−1.5	2.689	2.683	2.689	22
−1.0	2.718	2.704	2.713	17
−0.5	....	2.735	2.741	11
0.0	....	2.815	2.772	5
σ	±0.58	±0.60	....	....

Figures 27 and 28 give the color–absolute-magnitude diagrams for all stars retained as members and without peculiarities; the absolute magnitudes obtained from the β calibration were used. The value of σ is now ± 0.38 mag for both curves. On the other hand, if we consider only the stars used in Figures 12 and 13, we get standard deviations equal to ± 0.34 and ± 0.36, somewhat smaller than those obtained in the curves already mentioned. The contributions to this value of σ, made by the errors in the magnitudes due to the probable errors in β is of the order of ± 0.14. In all, there is an improvement which indicates that β-based absolute magnitudes are reliable.

Figures 29, 30, and 31 show an attempt to determine the shape of this group of stars. Figure 29 is drawn in old galactic coordinates. Dots represent the stars retained as members or probable members. The dotted lines represent the six areas selected by Blaauw, in which most of the observed stars are located. Seven stars in the southern part of area 1 are located rather far from the main body of the group; they are HD 139160, 168905, 170465, 172910, 175362, 178322, 180885, and 186837; of these, HD 172910 and 175362 are certain members according to Blaauw and HD 178322 is a probable member. This could imply the presence of other members in the vicinity. The crosses represent the stars observed outside the six areas and rejected as members; they were drawn to

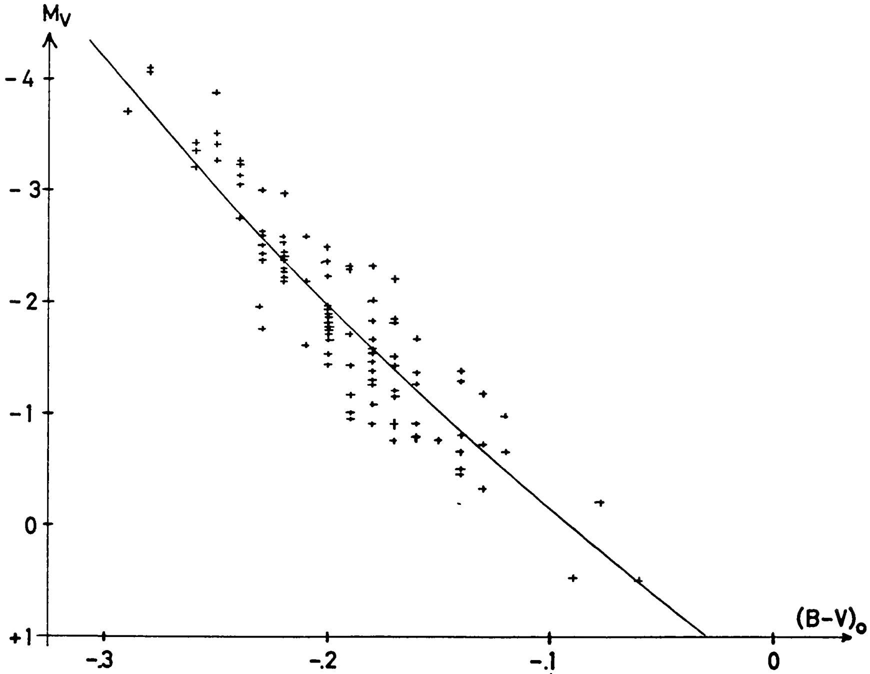


FIG. 27.—Color–absolute-magnitude diagram for $(B-V)_0$ for all stars retained as members, using the absolute magnitudes obtained from the β calibration.

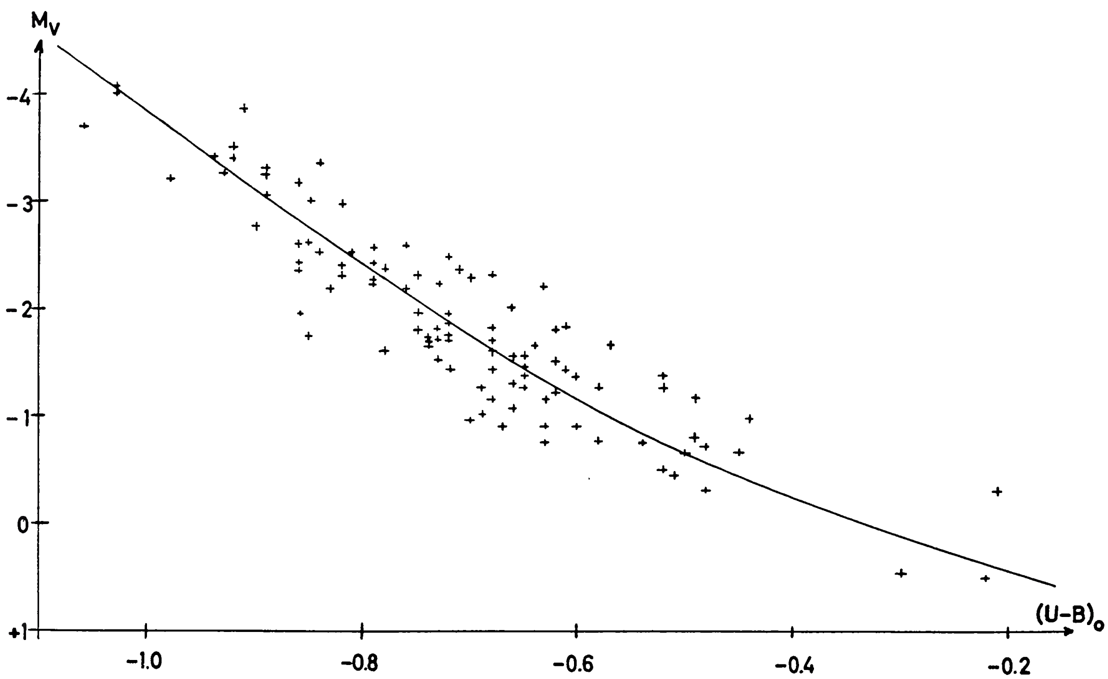


FIG. 28.—The same as Fig. 27, for $(U-B)_0$

show how far from the accepted main body this research was extended; in addition sixteen stars were observed in the gap in area 1 and rejected as members. So it seems that the seven stars mentioned above are part of a rather isolated group. Note also that the eleven faint stars observed in area 3 had to be rejected as members on account of their location in the color–apparent-magnitude diagrams.

Figure 30 is a projection of the dots on the plane passing through AB and perpendicular to the plane of Figure 29; β distance moduli were used in the ordinates; the abscissae are measured from A in arbitrary units. The crosses represent the stars rejected as members on the basis of the motions and with distance moduli smaller than 5.5 or larger than 7.0. They were plotted to show how far in distance the investigation was extended. The distances used for these stars were those obtained from photometry and the spectral

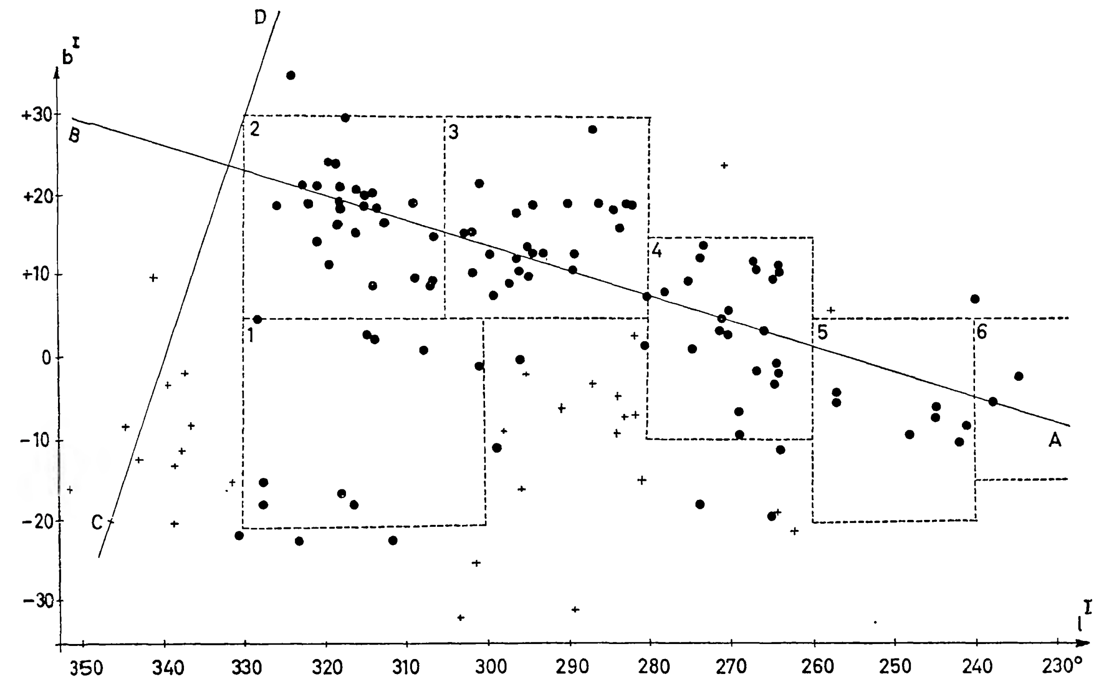


FIG. 29.—Distribution in space of the stars retained as members or probable members. For explanation see the text. The line AB is an approximate axis of symmetry of the group. No attempt has been made to draw an axis of symmetry perpendicular to AB, since the distribution of the stars does not show clearly its location. CD was drawn perpendicular to AB in an arbitrary position. The old galactic coordinates shown correspond to approximately $l^{II} = 260°$ to 20°.

class. No members have been found for distance moduli smaller than 4.95 or larger than 7.60.

Figure 31 shows the projection of the dots of Figure 28 on the plane perpendicular to that of Figure 29; the origin is taken at C. From these three figures we see that, except for the seven stars south of area 1, the group has an elongated shape, with the main plane of symmetry forming an angle of about 18° with the galactic plane and crossing it at about $l^{I} = 255°$ ($l^{II} = 287°$). The length of the main body is about 100° and its thickness is of the order of 25°. Taking a mean distance modulus of 6.18 mag, corresponding to 172 pc, these dimensions correspond approximately to 400 and 80 pc, respectively. The maximum scatter in distance is about 2.5 mag. The lack of symmetry of the drawing in Figure 29 suggests the possibility of extending the search for members along the line AB to higher galactic longitudes and latitudes, although the conclusions obtained by Blaauw (1946) indicate that the boundary of the association lies at about old galactic longitude 340°.

V. CONCLUSIONS AND FUTURE NEEDS

The main conclusions we have obtained may be summarized as follows: (1) A total of 102 stars were retained as members or probable members of the association from the three color and Hβ photometry; none of the faint late B-type stars in area 3 were found to be members. The star ζ Oph, which could be accepted as a member from the three-color-photometry and the radial velocity, has a proper motion which disagrees: it is one of the so-called run-away stars (Blauuw 1961); it has a genetic relation with the association and, if it could be considered as a member, it would be the younger star in the association. (2) The stars with known parallaxes suggest an age greater than 20×10^6 years. (3) The distribution of the interstellar absorption in the association is not regular;

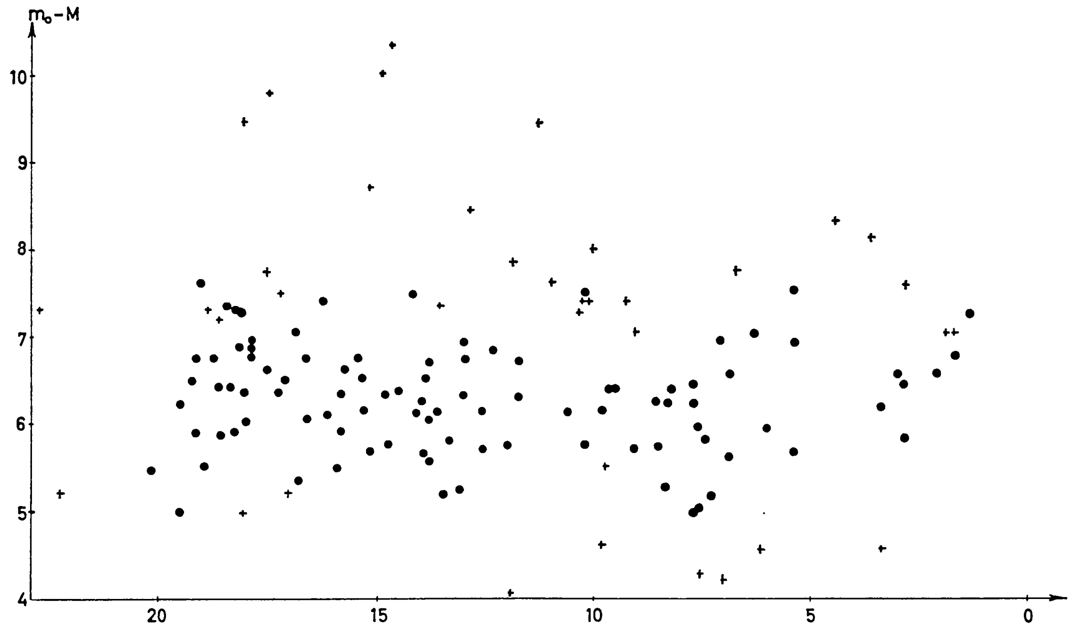


FIG. 30.—Projection of the dots in Fig. 29 on the plane passing through AB and perpendicular to the plane of Fig. 29. β distance moduli were used. The graph shows the concentration of the members in distance.

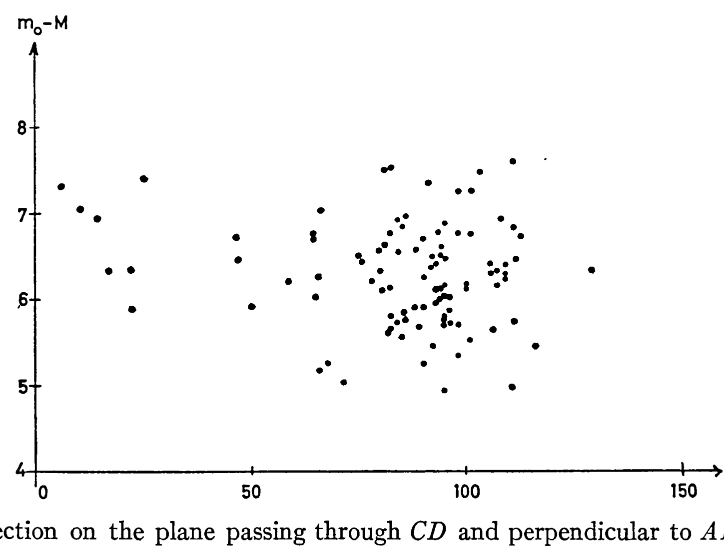


FIG. 31.—Projection on the plane passing through CD and perpendicular to AB (see Figs. 29 and 30).

strong condensations are present near ρ Oph and σ Sco, and a study of the value of R in this region gives a ratio of total to selective absorption which is abnormally high, close to 6.0. (4) The cluster has an elongated shape, with the main plane of symmetry forming an angle of about 18° with the galactic plane. (5) Hβ calibration of luminosities improves the distance moduli.

Future needs would be the following: (1) The extension of the photoelectric photometry to faint stars in different regions of the association; the selection could be made, for example, taking all stars of the HD catalogue down to magnitude 9.0 and with spectral type B9 or earlier; or else, it could be made on the basis of a spectral classification made from objective-prism observations. (2) The extension of *UBV* and Hβ photometry to regions of higher galactic latitude and longitude. (3) It would be valuable to obtain proper motions for those stars which are possible members but which do not yet have reliable proper motions; the same could be said concerning radial velocities. (4) It would be desirable to observe as many stars as possible in the Upper Scorpius region; these observations should be made in six-color photometry, extended to cover the infrared region, with the aim of obtaining an improved value of the ratio of total to selective absorption.

The authors wish to thank Dr. A. Blaauw for reading the manuscript and for his valuable suggestions with respect to present and future programs; Dr. W. Buscombe for some interesting talks and for the radial velocities he made available from Mount Stromlo Observatory; Dr. J. B. Irwin for his advice and encouragement; and Dr. J. Stock for suggesting this problem, for the facilities he made available for the observation at Cerro Tololo Inter-American Observatory, and for many interesting discussions. Thanks are also due to Mr. Klaus Czuia for drawing all the plots.

TABLE 10

PHOTOMETRIC CATALOGUE

HD	Name	(B−V)	(U−B)	V	n
70839*	....	−0.087	−0.822	6.97	3
72350	....	−0.022	−0.508	6.31	3
72555	....	−0.140	−0.724	6.79	3
73390*	e′ Car	−0.134	−0.625	5.26	3
74455*	....	−0.168	−0.922	5.49	4
74560	....	−0.167	−0.654	4.82	4
75149	....	+0.277	−0.535	5.46	4
75311	f Car	−0.182	−0.729	4.48	4
76161	....	−0.142	−0.592	5.90	4
77002	b′ Car	−0.188	−0.750	4.91	4
77320	....	−0.167	−0.794	6.06	3
79351*	a Car	−0.188	−0.712	3.41	3
79447	i Car	−0.183	−0.692	3.94	3
80094*	....	−0.104	−0.435	6.00	3
80781	....	−0.105	−0.550	6.26	3
81188*	κ Vel	−0.181	−0.770	2.47	3
83944*	m Car	−0.058	−0.229	4.49	3
83979	ζ Cha	−0.146	−0.587	5.14	5
84461*	O Vel	−0.041	−0.085	5.54	3
84816*	....	−0.169	−0.720	5.54	3
85980*	....	−0.115	−0.569	5.70	3
86440	Φ Vel	−0.100	−0.614	3.54	3
86466	....	−0.128	−0.611	6.12	3
86659	....	−0.098	−0.625	6.18	3
87152	....	−0.143	−0.691	6.20	3
88206*	Q Vel	−0.129	−0.685	4.85	5
88907	....	−0.118	−0.665	6.41	3
88955*	q Vel	+0.061	+0.042	3.84	5
89080*	ω Car	−0.083	−0.285	3.30	3
89104	....	−0.172	−0.771	6.16	3
93163	....	−0.005	−0.558	5.76	3
93194	....	−0.152	−0.618	4.80	3
93237*	....	−0.056	−0.521	5.94	5
93607	....	−0.152	−0.675	4.84	3
93845	δ^2 Cha	−0.192	−0.728	4.42	5
98718*	π Cen	−0.161	−0.615	3.89	3
99264	....	+0.042	−0.596	5.58	4
99556	....	−0.078	−0.568	5.28	5
100929	....	−0.100	−0.632	5.84	3
102776*	j Cen	−0.157	−0.631	4.34	3
103079	....	−0.122	−0.598	4.88	3
103884*	....	−0.170	−0.668	5.56	3
104841*	θ^2 Cru	−0.098	−0.637	4.70	3
104878*	....	−0.014	−0.201	5.34	3
105382*	....	−0.172	−0.701	4.45	6
105416*	E Cen	−0.021	−0.045	5.34	3
105435*	δ Cen	−0.134	−0.878	2.51	3
105580	....	−0.056	−0.542	7.14	3
105937*	ρ Cen	−0.167	−0.650	3.94	3
106490	δ Cru	−0.235	−0.921	2.78	3
106983	ζ Cru	−0.180	−0.718	4.05	3
107696*	....	−0.104	−0.423	5.37	3
108257*	....	−0.144	−0.654	4.81	3
108483	σ Cen	−0.202	−0.805	3.91	3
109026	γ Mus	−0.158	−0.634	3.85	3
109668*	α Mus	−0.219	−0.854	2.69	3
110335	....	−0.039	−0.409	4.92	3
110879	β Mus	−0.198	−0.766	3.05	3
110956	....	−0.165	−0.667	4.64	3
111123	β Cru	−0.243	−1.009	1.29	3
111597*	p Cen	−0.033	−0.126	4.91	3
111613	....	+0.387	−0.085	5.74	6

TABLE 10—*Continued*

HD	Name	$(B-V)$	$(U-B)$	V	n
112078......	λ Cru	−0.160	−0.628	4.63	3
112091......	μ^2 Cru	−0.065	−0.558	4.96:	3
112092......	μ^1 Cru	−0.194	−0.783	4.06:	4
113314*.....	ξ^1 Cen	+0.030	+0.014	4.83	3
113703......	f Cen	−0.142	−0.599	4.69	3
113791......	ξ^2 Cen	−0.197	−0.810	4.30:	4
115823......	....	−0.130	−0.533	5.45	3
115846......	....	−0.049	−0.554	7.06	3
116072......	....	−0.006	−0.605	6.27:	3
116087*.....	J Cen	−0.145	−0.631	4.58:	3
116226......	....	−0.075	−0.459	6.38	3
118716......	ε Cen	−0.246	−0.939	2.34	3
118978*.....	....	−0.042	−0.250	5.43	3
119069......	....	−0.198	−0.980	8.42	3
119338......	....	−0.078	−0.533	8.94	3
119644......	....	−0.083	−0.531	8.12	3
120307......	ν Cen	−0.234	−0.891	3.40	3
120324*.....	μ Cen	−0.205	−0.854	3.42	3
120640......	....	−0.160	−0.772	5.77	3
120908......	....	+0.007	−0.428	5.89	3
120955......	h Cen	−0.127	−0.554	4.78:	3
121190*.....	....	−0.080	−0.315	5.71	3
121292......	....	−0.031	−0.305	9.03	3
121743*.....	φ Cen	−0.222	−0.851	3.81	3
121790*.....	υ′ Cen	−0.212	−0.832	3.85	3
121983......	....	−0.110	−0.741	8.10	3
122159......	....	−0.020	−0.281	8.59	3
122324......	....	+0.348	−0.588	9.09	3
122449......	....	−0.066	−0.428	8.14	3
122479......	....	−0.063	−0.637	7.36	3
122925......	....	−0.026	−0.397	8.11	3
122980......	χ Cen	−0.203	−0.799	4.34	3
123130......	....	+0.011	−0.311	8.74	3
123335*.....	....	+0.038	−0.525	6.35	3
124182......	....	−0.032	−0.577	6.95	3
124197......	....	−0.041	−0.528	6.74	3
124367*.....	....	−0.087	−0.647	5.10	3
124771*.....	ε Aps	−0.121	−0.610	5.06	3
125238......	ι Lup	−0.180	−0.742	3.54	3
125288......	v Cen	+0.101	−0.430	4.36	4
125721......	....	−0.140	−0.913	6.10	3
125823......	a Cen	−0.197	−0.774	4.40	3
126341......	τ′ Lup	−0.160	−0.813	4.55	3
126981......	....	−0.082	−0.269	5.51	3
127972*.....	η Cen	−0.215	−0.862	2.35	3
128293*.....	....	−0.055	−0.880	6.76	3
129056*.....	α Lup	−0.217	−0.893	2.34	3
129116*.....	b Cen	−0.177	−0.727	4.00	3
129954......	....	−0.110	−0.722	5.90	3
130807......	o Lup	−0.156	−0.641	4.33	3
131058......	ζ Cir	−0.073	−0.617	6.08	3
131120......	....	−0.168	−0.737	5.02	3
131492*.....	θ′ Cir	−0.004	−0.788	5.11	3
132058*.....	β Lup	−0.226	−0.902	2.71	3
132200......	κ Cen	−0.204	−0.805	3.14	3
132955......	....	−0.123	−0.629	5.44	3
133937*.....	....	−0.115	−0.473	5.83	3
133955......	λ Lup	−0.170	−0.703	4.07	3
134687*.....	e Lup	−0.175	−0.706	4.83	3
135160......	....	−0.085	−0.918	5.74	3
135737*.....	....	−0.104	−0.632	6.29	3
136298......	δ Lup	−0.224	−0.910	3.22	3
136504*.....	ε Lup	−0.195	−0.778	3.41:	3

TABLE 10—*Continued*

HD	Name	$(B-V)$	$(U-B)$	V	n
136664......	ϕ^2 Lup	−0.149	−0.664	4.53	3
137387*.....	κ^1 Aps	−0.128	−0.791	5.52	3
137432*.....	....	−0.141	−0.612	5.44	3
138485*.....	ζ Lib	−0.145	−0.770	5.52	3
138690*.....	γ Lup	−0.216	−0.840	2.81	3
138764*.....	....	−0.088	−0.473	5.16	6
138769......	d Lup	−0.179	−0.726	4.54	3
139094......	....	+0.079	−0.293	7.39	3
139160*.....	....	−0.012	−0.437	6.21	3
139365*.....	τ Lib	−0.179	−0.717	3.68	3
139486......	....	+0.035	−0.082	7.63	3
140008......	ψ^2 Lup	−0.146	−0.570	4.75	3
140543......	....	−0.022	−0.892	8.88	3
141168......	....	−0.071	−0.238	5.78	4
141318......	....	+0.042	−0.723	5.75	4
141404......	....	+0.133	+0.051	7.71	3
141556*.....	χ Lup	−0.039	−0.133	3.97	3
141637*.....	1 Sco	−0.066	−0.742	4.64	3
141774......	....	+0.087	−0.101	7.70	3
142096*.....	λ Lib	−0.023	−0.584	5.03	3
142114......	2 Sco	−0.078	−0.665	4.60	3
142139*.....	....	+0.076	+0.048	5.78	3
142165*.....	....	−0.018	−0.418	5.39	3
142184*.....	....	−0.036	−0.608	5.41	6
142250......	....	−0.063	−0.456	6.16	3
142301......	3 Sco	−0.063	−0.599	5.88	3
142315......	....	+0.046	−0.227	6.87	4
142378......	47 Lib	−0.007	−0.548	5.96	3
142669......	ρ Sco A	−0.197	−0.833	3.88	3
142805......	....	+0.168	+0.058	7.14	3
142883......	....	+0.026	−0.500	5.86	3
142884......	....	+0.018	−0.496	6.78	3
142983......	48 Lib	−0.089	−0.260	4.95	3
142990*.....	....	−0.092	−0.656	5.44	3
143018......	π Sco	−0.187	−0.918	2.89	St.
143118......	η Lup	−0.226	−0.879	3.42	4
143275......	δ Sco	−0.124	−0.920	2.31	St.
143567......	....	+0.095	−0.108	7.18	3
143600......	....	+0.101	−0.069	7.32	4
143699......	....	−0.145	−0.603	4.90	3
144294......	θ Lup	−0.184	−0.734	4.22	3
144334......	....	−0.082	−0.571	5.91	3
144470......	ω^1 Sco	−0.042	−0.826	3.95	6
144661*.....	....	−0.055	−0.529	6.34	4
144844*.....	....	+0.016	−0.328	5.88	4
145102......	....	+0.064	−0.180	6.60	3
145353......	....	+0.140	−0.090	6.97	3
145482......	13 Sco	−0.163	−0.759	4.58	3
145502......	ν^1 Sco	+0.037	−0.667	4.00:	3
145519......	....	+0.255	−0.015	7.99	3
145554......	....	+0.145	−0.097	7.66	6
145631......	....	+0.142	−0.054	7.59	6
145792......	....	+0.034	−0.458	6.40	3
146001......	....	+0.037	−0.375	6.07	3
146029......	....	+0.088	−0.066	7.38	3
146284......	....	+0.146	−0.158	6.71	3
146285......	....	+0.222	−0.102	7.93	3
146332......	....	+0.192	−0.337	7.63	3
146416......	....	+0.016	−0.168	6.62	3
147009......	....	+0.300	+0.141	8.04	3
147010......	....	+0.162	−0.274	7.38	3
147084......	o Sco	+0.831	+0.688	4.56	3
147152......	....	−0.043	−0.429	5.33	3

TABLE 10—*Continued*

HD	Name	$(B-V)$	$(U-B)$	V	n
147196......	....	+0.161	−0.144	7.06	3
147701......	....	+0.544	−0.081	8.36	3
147888......	ρ Oph D	+0.291	−0.356	6.74	3
147889......	....	+0.806	−0.194	7.90	3
147890......	....	+0.214	−0.100	7.66	4
148184*.....	χ Oph	+0.270	−0.777	4.42	3
148199......	....	+0.081	−0.179	7.04	3
148379*.....	....	+0.546	−0.436	5.35	3
148478......	α Sco	+1.817	+1.202	1.07	45
148579......	....	+0.259	−0.020	7.32	3
148594......	....	+0.103	−0.254	6.88	3
148605*.....	22 Sco	−0.129	−0.731	4.77	3
148703*.....	N Sco	−0.178	−0.820	4.25	3
148860......	....	+0.156	−0.050	8.03	3
148937......	....	+0.323	−0.682	6.74	3
149438......	τ Sco	−0.252	−1.039	2.82	3
149711......	....	−0.024	−0.609	5.83	3
149757*.....	ζ Oph	+0.009	−0.866	2.57	St.
150898......	....	−0.081	−0.951	5.58	3
151346......	....	+0.406	−0.166	7.90	3
151890......	μ^1 Sco	−0.202	−0.859	3.04	3
151985......	μ^2 Sco	−0.219	−0.878	3.56	3
153613*.....	....	−0.096	−0.370	5.03	3
153716......	....	−0.099	−0.575	5.73	3
154090......	k Sco	+0.252	−0.696	4.85	3
154368......	....	+0.500	−0.531	6.13	3
154481*.....	....	−0.040	−0.257	6.29	3
155450......	....	+0.055	−0.787	6.02	3
156325......	....	+0.149	−0.361	6.36	5
156838......	....	−0.151	−0.776	5.70	3
157056*.....	θ Oph	−0.211	−0.872	3.26	3
157243......	....	−0.065	−0.406	5.12	3
157246*.....	γ Ara	−0.155	−0.954	3.33	3
158408......	υ Sco	−0.221	−0.854	2.70	5
158427......	α Ara	−0.186	−0.707	2.95	3
158926......	λ Sco	−0.231	−0.915	1.61	5
159358......	....	+0.021	−0.163	5.55	2
160578*.....	κ Sco	−0.228	−0.914	2.40	3
161756*.....	....	+0.122	−0.444	6.35	2
165024......	θ Ara	−0.109	−0.870	3.67	3
165516......	....	+0.103	−0.798	6.23	3
165793......	....	−0.051	−0.862	6.60	3
167128*.....	....	−0.055	−0.713	5.33	3
167263......	....	+0.009	−0.887	5.95	3
167264......	....	+0.030	−0.873	5.34	3
168905......	....	−0.180	−0.715	5.23	3
170235......	....	+0.041	−0.702	6.64	3
170465*.....	δ^1 Tel	−0.121	−0.438	4.94	3
170523*.....	δ^2 Tel	−0.141	−0.577	5.07	3
171034*.....	....	−0.121	−0.707	5.28	3
172910......	....	−0.176	−0.756	4.84	3
173117*.....	....	+0.037	−0.343	5.83	3
173375......	....	+0.179	−0.323	7.15	3
173948*.....	λ Pav	−0.167	−0.882	4.22	3
175191......	σ Sgr	−0.204	−0.761	2.10	3
175362......	....	−0.148	−0.702	5.37	5
175876......	....	−0.127	−1.008	6.94	3
178322*.....	....	−0.080	−0.484	5.87	3
180885*.....	....	−0.128	−0.584	5.59	3
182180*.....	....	−0.129	−0.691	6.04	3
183133*.....	....	−0.035	−0.564	6.77	3
186219*.....	....	+0.231	+0.079	5.42	3
186837......	....	−0.142	−0.571	6.21	3

REMARKS TO TABLE 10

No duplicity corrections have been applied. Stars with an asterisk have variable radial velocities.

75311 Suspected variable.
77002 5.1:7.5, 40″.
79351 Spectroscopic binary.
81188 Spectroscopic binary.
85980 5.9:8.0, 5″.
98718 4.7:5.5, 0″.2.
103079 5.2:7.8, 2″.
103884 Suspected variable.
104841 Spectroscopic binary.
105382 Magnitude 6.5, B9 at 368″, common proper motion.
105435 Suspected variable.
106490 Suspected variable.
109668 Suspected variable.
110335 Suspected variable.
110879 3.9:4.2, 2″.
110956 4.9:9.2 at 53″.
111123 Variable, 1.02 to 1.08, period 0ᵈ28. The value of V given is the mean of 1.30, 1.28, and 1.27.
111613 Probable error in $V \pm 0.015$. Suspected variable.
112078 Probably spectroscopic binary.
112091, 112092 Double, distance 34″.3, combined magnitude 3.95. Both components observed with smaller diaphragm.
113703 Magnitude 10 at 12″.
113791 Magnitude 9 at 24″. Observed with smaller diaphragm. Spectroscopic binary.
116072, 116087 These stars together form CPD−60°4627, combined magnitude 4.7. Individual magnitudes 6.6 and 4.5. Observed with smaller diaphragm.
120307 Spectroscopic binary.
120324 Variable, 3.0 to 3.2, period not determined.
120955 4.8:9.2 at 15″. Observed with smaller diaphragm. Spectroscopic binary.
121743 Suspected variable.
124367 5.2:10.8, 34″.
125238 Suspected variable.
125721 6.3:9.4 at 4″.
126341 Variable, 4.1 to 4.14, period 0ᵈ18.
127972 Spectroscopic binary.
132200 3.4:11.5, 4″.
133955 5.0:5.4, 0″.2.
135160 6.0:9.0, 1″.2.
135737 6.6:9.0, 1″.3.
136298 Suspected variable.
136504 Triple, observed with smaller diaphragm.
137387 One value of $(U - B)$ disagrees; V varied from 5.45 to 5.61. According to HD catalogue, probably spectroscopic binary.
137432 Double, 5.5:14.0.
138485 Double.
138690 3.6:3.8, 0″.1.
138764 Probable error in $V \pm 0.008$; probably spectroscopic binary.
138769 4.9:7.6, 2″.
140008 Double.
141318 5.8:8.6, 19″. Observed with smaller diaphragm.
142114 4.8:7.8, 3″.
142378 6.1:7.6, 0″.5.
142669 Double, 4.0:14.5.
142983 Only two V observations. Suspected variable.
142990 Only two V observations.
143018 Spectroscopic binary.
143118 3.6:7.7, 15″. The values given in the catalogue refer to both components together.
143275 Spectroscopic binary.
143699 Only two V observations.
144844 Suspected variable.
145502 Quadruple star; the observations represent A + B together; observed with smaller diaphragm.
145631 Probable error in $(U - B)$ and $V \pm 0.013$. Variable?
146332 9″ visual binary, $\Delta m = 7$ mag.
147701 3″ visual binary, $\Delta m = 5$ mag.
147888 1″ visual binary, $\Delta m = 1$ mag.
147890 4″ visual binary, $\Delta m = 6$ mag.
148184 Nova-like variable.
148478 Double, 7th magnitude companion at 3″. Spectroscopic binary; besides, semiregular red supergiant, 0.9 to 1.8 mag., period 1733 days. The values we obtained ranged as follows: $(B - V)$: +1.790 to +1.837; $(U - B)$: +1.147 to +1.239; V: 1.16 to 0.99.
149711 6.1:9.3, 16″; the results refer to both components together.
151890 Eclipsing and spectroscopic binary in which both components are bright. Photographic magnitude changes from 3.0 to 3.3 in a period of 1.44 days. The value of V given is the mean of 2.94, 3.22, and 2.95.
154090 Double, 4.9:14.0.
154368 6.3:12.0, 3″.
157056 Suspected variable.
157246 Magnitude 10 at 18″.
167263 6.0:12.0, 6″.
173948 Suspected variable.

TABLE 11

INTRINSIC PHOTOMETRIC DATA AND MEMBERSHIP CRITERIA FOR ALL OBSERVED STARS

HD	$(B-V)_0$	$(U-B)_0$	V_0	Spectral Types				Membership			
				S_Q	Bertiau	de Vaucouleurs	Morris	Pho	Motion μ	Motion V_r	Mod
70839	−0.25	−0.94	6.47	B1	...	...	B3 III	*c*	*c*	...	*a*
72350	−0.16	−0.60	5.88	B4	...	...	B5 IV	*a*	...	*b*	*b*
72555	−0.21	−0.77	6.58	B2	...	...	B4 V	*c*	...	...	*c*
73390	−0.18	−0.65	5.12	B3	...	...	B3 Vn	*a*	...	*b*	*a*
74455	−0.27	−0.99	5.19	B1	...	...	B3 Vn	*c*	...	*b*	*a*
74560	−0.18	−0.66	4.78	B3	...	...	B4 IV	*a*	...	*a*	*a*
75149	−0.22	−0.95	3.96	...	...	...	B2 II	*b*	...	*b*	*c*
75311	−0.20	−0.74	4.42	...	...	B3 Vne	B2 Vn	*a*	...	*b*	*a*
76161	−0.17	−0.61	5.83	B4	...	...	B6: Vn	*a*	*b*	*b*	*a*
77002	−0.21	−0.76	4.85	B3	...	B3 IV	...	*a*	*c*	*b*	*a*
77320	−0.23	−0.83	5.88	B2	...	...	B2.5 Vn	*c*	...	...	*b*
79351*	−0.20	−0.72	3.39	B3	...	B2 IV	...	*a*	*a*	*a*	*a*
79447	−0.19	−0.70	3.92	B3	...	B3 IV	...	*a*	...	*a*	*a*
80094	−0.12	−0.45	5.94	B7	...	...	B7 IV	*a*	...	*a*	*a*
80781	−0.16	−0.58	6.10	B4	...	...	B7 IV	*a*	...	*a*	*a*
81188	−0.22	−0.79	2.37	B2	...	B2 IV	...	*a*	*b*	*a*	*b*
83944	−0.06	−0.23	4.48	B9	...	B9 V	...	*c*	...	*a*	*c*
83979	−0.16	−0.60	5.08	B4	...	...	B5 IV	*a*	*a*	*c*	*a*
84461	−0.02	−0.07	5.58	B9.5	...	A0 V	...	*b*	...	*a*	*c*
84816	−0.20	−0.74	5.44	B3	...	B2: Vn	B3 V	*a*	...	*c*	*b*
85980*	−0.16	−0.60	5.55	B4	...	B3 V	B4 V	*a*	*a*	*a*	*a*
86440	−0.14	−0.69	3.42	...	...	B5 I–II	B5 II	*b*	*b*	*a*	*b*
86466	−0.18	−0.64	5.98	B4	...	...	B3 V	*b*	*c*	*a*	*c*
86659	−0.19	−0.68	5.91	B3	...	...	B4 IV	*b*	*c*	*a*	*a*
87152	−0.20	−0.73	6.03	B3	...	...	...	*c*	*c*	*b*	...
88206	−0.20	−0.73	4.64	B3	...	...	B2 V	*a*	*b*	*b*	*a*
88907	−0.20	−0.72	6.18	B3	...	B3 Vn	...	*c*	*c*	*a*	*c*
88955	0.00	0.00	3.66	...	...	A2 V	...	*c*	*c*	*b*	*c*
89080	−0.08	−0.28	3.32	B8	...	B7 IV	...	*c*	*b*	*a*	*c*
89104	−0.22	−0.80	6.02	B2	...	...	...	*c*	*b*	*b*	...
93163	−0.18	−0.68	5.22	B3	...	B3: V	...	*a*	*b*	*b*	*a*
93194	−0.17	−0.63	4.73	B4	...	B5 Vn	...	*a*	...	*b*	*a*
93237	−0.16	−0.59	5.63	B4	...	...	B5 V	*a*	...	*c*	*a*
93607	−0.19	−0.70	4.72	B3	...	B4 IV	B3 IV	*a*	...	*a*	*a*
93845	−0.20	−0.73	4.39	B3	...	B3 V	...	*a*	*a*	*b*	*a*
98718	−0.17	−0.62	3.86	B4	...	B6 Vn	...	*a*	*a*	*a*	*c*
99264	−0.21	−0.76	4.84	B3	...	...	B3 III	*a*	*a*	...	*a*
99556	−0.17	−0.63	5.00	B4	...	B5 IV	...	*a*	*c*	*a*	*a*
100929	−0.19	−0.69	5.58	B3	...	B3 IV	...	*a*	*c*	*a*	*b*
102776	−0.20	−0.71	4.21	...	...	B3: Vne	B3 Vne	*a*	...	*b*	*a*
103079	−0.17	−0.63	4.72	B4	...	B4 IV	...	*a*	*a*	*b*	*a*
103884*	−0.19	−0.68	5.52	B3	...	B3 V	...	*a*	*a*	*a*	*a*
104841	−0.19	−0.70	4.43	B3	...	B2 IV	B3 IV	*a*	*c*	*c*	*a*
104878	−0.06	−0.23	5.19	B9	...	...	A0 V	*b*	...	*c*	*c*
105382*	−0.20	−0.72	4.38	B3	dB7:	B6 III–IV	B6 III	*a*	*a*	*a*	*a*
105416	−0.01	−0.04	5.37	A0	...	...	A1 V	*a*	...	*b*	*c*
105435*	−0.22	−0.78	2.25	...	B2: V:pe	B3 Vne	...	*a*	*a*	*a*	*a*
105580	−0.17	−0.61	6.80	B4	...	...	B6 V	*c*	...	...	*a*
105937	−0.18	−0.66	3.90	B3	...	B4 V	...	*a*	*a*	*b*	*a*
106490	−0.25	−0.93	2.72	B1	B2 V	B2 IV	B2 III	*a*	*a*	*b*	*a*
106983*	−0.20	−0.73	3.99	B3	...	B3 IV	...	*a*	*a*	*a*	*a*
107696	−0.09	−0.30	5.37	...	...	...	B8 Vp	*a*	...	*c*	*c*

TABLE 11—*Continued*

HD	$(B-V)_0$	$(U-B)_0$	V_0	Spectral Types				Membership			
				S_Q	Bertiau	de Vaucouleurs	Morris	Pho	Motion		Mod
									μ	V_r	
108257	−0.19	−0.68	4.68	B3	...	B5 Vn	...	*a*	*a*	*b*	*a*
108483	−0.22	−0.82	3.85	B2	B2 V	B3 Vn	...	*a*	*a*	*b*	*a*
109026	−0.18	−0.65	3.79	B4	...	B5 V	...	*a*	*a*	*a*	*b*
109668*	−0.23	−0.86	2.64	B2	B2 V	B3 IV	B2 IV	*a*	*a*	*a*	*a*
110335	−0.13	−0.46	4.66	B6	...	...	B7 IV	*b*	...	*a*	*a*
110879	−0.21	−0.78	3.01	B2.5	...	...	B2.5 V	*a*	*a*	*c*	*c*
110956	−0.19	−0.68	4.58	B3	...	B3 IV	...	*a*	*a*	*a*	*a*
111123	−0.28	−1.03	1.18	B0.5	B0.5 III	B0.5 IV	...	*a*	*a*	*a*	*a*
111597	−0.04	−0.13	4.90	B9.5	...	A0 IV	...	*c*	*a*	*c*	*c*
111613	+0.04	...	4.70	...	...	...	A1 Ia	*c*	...	*c*	*c*
112078*	−0.18	−0.64	4.59	B4	...	B5: Vn	...	*a*	*a*	*a*	*a*
112091	−0.16	−0.56	4.68:	...	...	B5 Ve	...	*a*	*a*	*a*	*a*
112092	−0.22	−0.80	3.99:	B2	...	B3 IV	...	*a*	*b*	*a*	*a*
113314	0.00	−0.01	4.74	A0	...	...	A0 V	*c*	...	*b*	*c*
113703*	−0.17	−0.62	4.61	B4	B5 V	B4 IV	B5 IV	*a*	*a*	*a*	*a*
113791	−0.22	−0.83	4.21:	B2	B2 V	B2 IV	...	*a*	*b*	*a*	*a*
115823	−0.15	−0.54	5.39	B5	...	B5 III	B5 III	*a*	*a*	*b*	*a*
115846	−0.17	−0.64	6.68	B4	...	...	B4 V	*c*	...	...	*c*
116072	−0.20	−0.73	5.67:	B3	...	...	B4 Vn	*b*	*c*	*c*	*a*
116087	−0.18	−0.65	4.48:	B3	...	B5 V	...	*a*	*a*	*b*	*a*
116226	−0.14	−0.50	6.19	B6	...	...	B7 IV	*a*	*c*	*c*	*a*
118716	−0.26	−0.94	2.31	B1	B1 V	B1 V	...	*a*	*a*	*b*	*a*
118978	−0.07	−0.27	5.33	B8	...	...	B9 IV	*b*	...	*c*	*a*
119069	−0.28	−1.04	8.18	B0	...	...	...	*c*	...	...	...
119338	−0.16	−0.58	8.70	B4	...	...	...	*c*	...	...	...
119644	−0.16	−0.58	7.89	B4	...	...	...	*c*	...	...	...
120307*	−0.24	−0.90	3.37	B1	B2 IV	B2 V	B2 IV	*a*	*a*	*a*	*a*
120324*	−0.22	−0.78	3.38	...	B2 Vpne	B3 Ve	...	*a*	*a*	*a*	*a*
120640	−0.22	−0.81	5.58	B2	...	B4 III	...	*c*	*b*	*b*	*c*
120908*	−0.14	−0.52	5.44	B5	...	B5 V	...	*a*	*a*	*a*	*a*
120955*	−0.16	−0.57	4.68:	B4	B5 III	B5 IV	...	*a*	*a*	*a*	*a*
121190	−0.09	−0.32	5.68	B8	...	...	B8 V	*b*	...	*c*	*a*
121292	−0.10	−0 34	8.84	B7	...	...	...	*c*	...	...	...
121743*	−0.23	−0.86	3.78	B2	B2 IV	B2 V	...	*a*	*a*	*a*	*a*
121790	−0.23	−0.84	3.80	B2	B2 V	B3 IV	...	*a*	*a*	*a*	*a*
121983	−0.22	−0.82	7.76	B2	...	...	...	*c*	...	...	...
122159	−0.09	−0.32	8.39	B8	...	...	...	*c*	...	...	...
122324	−0.20	−1.04	7.44	...	...	...	...	*c*	...	...	*c*
122449	−0.13	−0.47	7.95	B6	...	...	...	*c*	...	...	...
122479	−0.20	−0.72	6.96	B3	...	...	...	*c*	...	...	...
122925	−0.13	−0.46	7.81	B6	...	...	...	*c*	...	...	...
122980*	−0.22	−0.81	4.29	B2	B2 V	B2 V	...	*a*	*a*	*a*	*a*
123130	−0.11	−0.38	8.39	B7	...	...	...	*c*	...	...	...
123335	−0.18	−0.67	5.69	B3	...	B5 IV	...	*a*	*b*	*b*	*a*
124182	−0.18	−0.67	6.50	B3	...	...	B6 IV	*c*	...	...	*c*
124197	−0.17	−0.61	6.36	B4	...	...	B6 V	*b*	...	*a*	*a*
124367	−0.20	−0.71	4.76	...	...	B3 Ve	...	*a*	...	*a*	*a*
124771	−0.18	−0.65	4.90	B4	...	B4 IV	...	*a*	...	*b*	*a*
125238	−0.21	−0.76	3.46	B3	...	B3 V	B3 IV	*a*	*c*	*c*	*a*
125288	−0.14	−0.69	3.63	...	...	B5 II	...	*b*	*c*	*a*	*b*
125721	−0.27	−1.00	5.70	B0.5	...	...	B3 V	*c*	...	*c*	*b*
125823*	−0.22	−0.79	4.35	B3	B3 V	B6 III	B5 III	*a*	*a*	*a*	*a*
126341	−0.24	−0.86	4.33	B2	...	...	B3 III	*a*	*a*	*b*	*a*
126981	−0.07	−0.26	5.54	B8	...	...	B6 IV+A1	*b*	...	*a*	*a*
127972	−0.24	−0.88	2.28	B2	...	B3 III	...	*a*	*a*	*b*	*b*

TABLE 11—*Continued*

HD	$(B-V)_0$	$(U-B)_0$	V_0	Spectral Types: S_Q	Spectral Types: Bertiau	Spectral Types: de Vaucouleurs	Spectral Types: Morris	Membership: Pho	Membership: Motion μ	Membership: Motion V_r	Membership: Mod
128293	−0.16	−0.56	6.44	...	...	...	B5: V:e	*c*	...	*c*	*a*
129056*	−0.25	−0.91	2.25	B1	B1 V	B1 III	...	*a*	*a*	*a*	*a*
129116*	−0.20	−0.74	3.92	B3	B3 V	B3 V	B3 IV	*a*	*a*	*a*	*a*
129954	−0.22	−0.79	5.58	B2	...	...	B2 V	*c*	...	*c*	*c*
130807*	−0.18	−0.66	4.25	B4	B6 III:	B6 III	...	*a*	*a*	*a*	*a*
131058	−0.19	−0.69	5.73	B3	...	B5 Vn	B4 V	*c*	...	*c*	*a*
131120	−0.21	−0.76	4.90	B3	...	...	B6 V	*a*	*a*	*a*	*a*
131492	−0.20	−0.71	4.52	...	...	B3 Vne	...	*c*	...	*a*	*a*
132058	−0.25	−0.92	2.64	B1	B2 IV	B2 V	...	*a*	*a*	*a*	*b*
132200*	−0.22	−0.82	3.08	B2	B2 V	B2 III	...	*a*	*a*	*a*	*a*
132955*	−0.18	−0.67	5.26	B3	B3 V	B4 IV	...	*a*	*a*	*a*	*a*
133937	−0.13	−0.48	5.78	B6	B7: V:nn	B6 V	...	*a*	*a*	*a*	*a*
133955	−0.20	−0.72	3.98	B3	B3 V	B3 IV	...	*a*	*a*	*b*	*a*
134687	−0.20	−0.72	4.77	B3	...	B3 III	...	*a*	...	*a*	*a*
135160	−0.26	−0.93	5.21	B0	...	...	B1 V	*c*	*c*	*a*	*c*
135737	−0.19	−0.69	6.04	B3	...	...	B3 V	*c*	...	*a*	*c*
136298*	−0.25	−0.93	2.97	B1	B2 IV	B3 IV	...	*a*	*a*	*a*	*a*
136504	−0.22	−0.79	3.35:	B2	...	B3 IV	B3 IV	*a*	...	*b*	*a*
136664*	−0.19	−0.69	4.42	B3	B5 V	B3 IV	...	*a*	*a*	*a*	*a*
137387	−0.23	−0.86	5.21	B2	...	...	B3 IV	*c*	*c*	*c*	*a*
137432	−0.17	−0.63	5.35	B4	B5 V	B4 V	...	*a*	*a*	*a*	*a*
138485	−0.22	−0.82	5.29	B2	B2 Vnn	B3 III	...	*c*	*a*	*b*	*a*
138690	−0.23	−0.85	2.76	B2	B2 Vn	B3 V	...	*a*	*a*	*b*	*a*
138764*	−0.14	−0.51	5.01	B5	B7 IV:	B6 IV	...	*a*	*a*	*a*	*a*
138769	−0.20	−0.74	4.47	B3	B5 IV	B3 IV	...	*a*	*a*	*a*	*a*
139094	−0.11	−0.42	6.81	B7	B8 IV	...	...	*a*	*c*	*a*	*a*
139160	−0.14	−0.52	5.82	B5	B8 V	...	B9 IV	*a*	*a*	*b*	*a*
139365	−0.20	−0.73	3.61	B2.5	B2.5 V	B4 V	...	*a*	*a*	*a*	*a*
139486	−0.04	−0.13	7.42	B9.5	B9.5 V	...	...	*a*	...	...	*a*
140008*	−0.16	−0.58	4.71	B4	B6 V	B6 V	...	*a*	*a*	*a*	*a*
140543	−0.29	−1.08	8.08	B0	B0.5 III	...	...	*c*	...	*a*	*c*
141168	−0.06	−0.23	5.80	B8	...	...	B8 V	*b*	*b*	*a*	*a*
141318	−0.25	−0.92	4.88	B1	...	B2 III	...	*c*	*c*	*b*	*c*
141404	−0.01	−0.04	7.28	A0	B9 V	...	...	*a*	...	*b*	*a*
141556	−0.04	−0.13	3.98	B9.5	...	A0 III–IV	...	*c*	*b*	*b*	*c*
141637	−0.23	−0.85	4.15	B2	B2.5 Vn	B3 V	...	*a*	*a*	*b*	*a*
141774	−0.05	−0.19	7.28	B9	B9 V	...	...	*a*	...	...	*a*
142096	−0.19	−0.69	4.53	B3	B3 V	...	...	*a*	*a*	*b*	*a*
142114	−0.20	−0.75	4.22	B3	B2.5 Vn	B3 Vn	...	*a*	*a*	*b*	*a*
142139	+0.03	+0.02	5.64	A0	...	...	A1 V	*c*	...	*c*	*c*
142165	−0.14	−0.49	5.04	B6	B6 V	B6 Vn	...	*a*	*a*	*a*	*a*
142184	−0.22	−0.78	4.87	...	B2 Vnn	B3 Vne?	...	*a*	*a*	*b*	*a*
142250	−0.14	−0.50	5.94	B5	B7 V	...	B7 V	*a*	...	*b*	*a*
142301	−0.19	−0.68	5.52	B3	B7 IV:	...	B8 IV	*a*	*c*	*a*	*a*
142315	−0.08	−0.31	6.48	B8	B9 V	...	...	*a*	*a*	*a*	*a*
142378	−0.18	−0.66	5.44	B3	B5 V:	...	B5 V	*a*	*a*	*a*	*a*
142669*	−0.23	−0.86	3.78	B2	B2 V	B3 IV	...	*a*	*a*	*a*	*a*
142805	−0.02	−0.06	6.59	B9.5	B9 V	...	...	*b*	*c*	...	*a*
142883	−0.17	−0.63	5.27	B4	B3: V	...	B3 V	*a*	*a*	*c*	*a*
142884	−0.17	−0.62	6.22	B4	...	...	...	*b*	...	...	...
142983	...	...	...	...	B p	...	...	...	*a*	*a*	*a*
142990	−0.20	−0.72	5.12	B3	B3: V	...	B8 V	*a*	*a*	*b*	*a*
143018	−0.26	−0.97	2.66	B0.5	B1 V	B2 IV	...	*a*	*a*	*a*	*a*
143118*	−0.24	−0.89	3.37	B1	B2 V	B3 V	B2 V	*a*	*a*	*a*	*a*
143275	−0.28	−1.03	1.85	B0	B0 V	...	B0 V	*a*	*a*	*a*	*a*

1968ApJS...15..459G

TABLE 11—*Continued*

HD	$(B-V)_0$	$(U-B)_0$	V_0	Spectral Types				Membership			
				S_Q	Bertiau	de Vaucouleurs	Morris	Pho	Motion		Mod
									μ	V_r	
143567....	−0.06	−0.20	6.73	B9	B9 V	...	...	*a*	...	*c*	*a*
143600....	−0.04	−0.23	6.89	B9	B9 V	...	...	*a*	...	...	*a*
143699....	−0.17	−0.62	4.82	B4	B7 IV:	B5 V	B5 IV	*a*	*a*	*a*	*a*
144294....	−0.20	−0.75	4.16	B3	B2 Vn	B3 IV	B3 IVn	*a*	*a*	*b*	*a*
144334....	−0.17	−0.63	5.64	B4	B9: III	...	B8 V	*a*	*a*	*b*	*a*
144470....	−0.26	−0.98	3.28	B1	B1 V	...	...	*a*	*a*	*a*	*a*
144661....	−0.16	−0.60	6.01	B4	B7 IV:	...	B7 V	*a*	*a*	*a*	*a*
144844....	−0.11	−0.41	5.49	B7	B9 V	...	...	*a*	*a*	...	*c*
145102....	−0.06	−0.19	6.23	......	B9 Vp	...	...	*b*	*a*	*b*	*a*
145353....	−0.06	−0.22	6.37	B9	B9 V	...	...	*b*	*c*	...	*a*
145482....	−0.22	−0.79	4.42	B2.5	B2.5 Vn	B3 Vn	...	*a*	*a*	*a*	*a*
145502....	−0.23	−0.85	3.20:	B2	B2 IV–V	B3 V	B3 IV	*a*	*a*	*a*	*a*
145519....	−0.06	−0.22	7.05	B9	...	...	...	*a*	...	...	...
145554....	−0.06	−0.23	7.04	B9	B9 V	...	...	*a*	...	...	*a*
145631....	−0.05	−0.18	7.02	B9	B9.5 V	...	...	*a*	*a*	...	*a*
145792....	−0.16	−0.58	5.82	B5	B7 IV	...	B6 V	*a*	*c*	*b*	*a*
146001....	−0.13	−0.48	5.56	B6	B8 IV	...	B8 IV	*a*	*a*	*b*	*a*
146029....	−0.04	−0.15	6.99	B9	B9 V	...	...	*a*	*a*	...	*a*
146284....	−0.08	−0.30	6.02	B8	B8 V	...	...	*a*	*c*	*c*	*a*
146285....	−0.08	−0.30	7.02	B8	B8 V	...	...	*a*	...	...	*a*
146332....	−0.14	−0.69	6.63	......	B5 II:	...	...	*c*	*b*	...	*c*
146416....	−0.06	−0.22	6.39	B9	B9.5 V	...	...	*a*	*a*	*b*	*a*
147009....	−0.02	−0.07	7.08	B9.5	B9.5 V	...	...	*b*	*c*	*a*	*a*
147010....	−0.13	−0.46	6.52	B6	...	...	...	*a*	...	*b*	...
147084....	+0.15	....	2.52	......	A5II	A5 III:	...	*c*	*a*	*b*	*a*
147152....	−0.13	−0.49	5.06	B6	...	B6 V	B6 IV	*a*	*b*	*a*	*a*
147196....	−0.08	−0.30	6.33	B8	B5 V	...	...	*a*	*b*	*c*	*a*
147701....	−0.14	−0.53	6.30	B5	...	...	...	*a*	...	...	...
147888....	−0.18	−0.67	5.32	B3	B3 V:	...	...	*a*	*a*	*b*	*a*
147889....	−0.26	−0.97	4.70	B0.5	B1.5 V	...	...	*c*	...	*a*	*b*
147890....	−0.08	−0.28	6.79	B8	A0	...	...	*a*	...	...	...
148184....	−0.21	−0.78	2.98	......	B2 V	B3 V:e	...	*a*	*a*	*a*	*a*
148199....	−0.08	−0.28	6.57	B8	...	...	...	*a*	...	...	...
148379....	−0.16	−0.96	3.24	......	...	...	B2 Ia	*b*	*c*	*a*	*c*
148478....	....	....	......	......	M2 I	...	...	...	*a*	*a*	*a*
148579....	−0.06	−0.22	6.36	B9	B9 V	...	...	*b*	...	...	*a*
148594....	−0.11	−0.39	6.25	B7	B9: V	...	...	*a*	*a*	...	*a*
148605....	−0.22	−0.79	4.51	B2.5	B2 V	...	...	*a*	*a*	*a*	*a*
148703*...	−0.23	−0.86	4.08	B2	B2 IV	B2 V	...	*a*	*a*	*a*	*a*
148860....	−0.05	−0.18	7.41	B9	...	...	...	*a*	...	...	...
148937....	−0.31	−1.15	4.85	O	...	...	O6f	*c*	...	*c*	*c*
149438*...	−0.29	−1.06	2.72	B0	B0 V	...	B0 V	*a*	*a*	*a*	*a*
149711....	−0.20	−0.72	5.31	B3	...	B3 III–IV	B3 IV	*a*	*b*	*a*	*a*
149757....	−0.29	−1.08	1.68	O9.5	...	...	O9.5 Vnk	*a*	*c*	*a*	*a*
150898....	−0.22	−1.05	5.16	......	...	...	B0 Ib	*c*	...	*c*	*c*
151346....	−0.14	−0.52	6.26	B5	...	...	...	*a*	...	...	...
151890*...	−0.24	−0.86	2.92	......	B1.5 V	B3 Vp	...	*a*	*a*	*a*	*a*
151985*...	−0.24	−0.89	3.49	B1	B2 IV	B2 IV	...	*a*	*a*	*a*	*a*
153613....	−0.10	−0.37	5.01	B7	...	B8 V	...	*b*	*c*	*a*	*c*
153716*...	−0.17	−0.62	5.52	B4	...	B4 V	B5 V	*a*	*a*	*a*	*a*
154090....	−0.25	−0.98	3.34	......	...	B1 II–III	...	*c*	*c*	*b*	*b*
154368....	−0.27	−1.10	3.80	......	...	O9.5 I–II	...	*c*	*c*	*b*	*c*
154481....	−0.08	−0.28	6.18	B8	...	A0 III–IV	...	*a*	*b*	*c*	*a*
155450....	−0.27	−1.02	5.03	B0.5	...	B1 III	...	*c*	*c*	*a*	*c*
156325....	−0.15	−0.55	5.46	B5	...	...	B6 IV	*a*	...	*a*	*a*

TABLE 11—*Continued*

HD	$(B-V)_0$	$(U-B)_0$	V_0	Spectral Types: S_Q	Spectral Types: Bertiau	Spectral Types: de Vaucouleurs	Spectral Types: Morris	Membership: Pho	Membership: Motion μ	Membership: Motion V_r	Membership: Mod
156838	−0.22	−0.82	5.48	B2	...	B2 V	...	*c*	*b*	*a*	*b*
157056	−0.24	−0.89	3.17	B1	B2 IV	B2 IV	...	*a*	*a*	*a*	*a*
157243	−0.12	−0.44	4.95	B6	...	B6 V	...	*b*	*b*	*c*	*a*
157246	−0.28	−1.04	2.95	B0.5	...	B1 III	...	*a*	*c*	*a*	*a*
158408	−0.12	−0.82	...	...	...	...	B3 Ib	...	*b*	*a*	*c*
158427	−0.20	−0.71	2.92	B3	...	B3 Vn	...	*a*	*c*	*a*	*b*
158926	−0.25	−0.93	1.55	B1	...	B2 IV	...	*a*	*b*	*c*	*c*
159358	−0.06	−0.21	5.31	B9	...	B8 V	...	*c*	*c*	*a*	*b*
160578	−0.25	−0.93	2.33	B1	...	B2 IV	...	*a*	*b*	*c*	*b*
161756	−0.17	−0.63	5.47	B4	...	...	B3 IV	*a*	*b*	...	*b*
165024	−0.26	−1.05	3.22	...	...	...	B0.5 II	*b*	*c*	*a*	*c*
165516	−0.18	−0.96	5.38	...	...	...	B1 Ibk	*b*	*c*	*a*	*c*
165793	−0.18	−0.96	6.21	...	...	...	B1 Ibk	*b*	...	...	*c*
167128	−0.22	−0.83	4.82	B2	...	B3 V	...	*b*	*c*	*c*	*a*
167263	−0.30	−1.10	5.04	...	...	...	...	*c*	...	*a*	*c*
167264	−0.30	−1.11	4.36	...	...	...	...	*c*	...	*a*	*c*
168905	−0.20	−0.73	5.17	B3	...	B3 Vn	...	*a*	*b*	*b*	*a*
170235	−0.24	−0.86	6.05	...	...	...	...	*c*	...	...	...
170465	−0.12	−0.44	4.94	B6	...	B6 IV	...	*b*	...	*b*	*a*
170523	−0.16	−0.59	5.01	B4	...	B5 IV	...	*a*	...	*a*	*a*
171034	−0.21	−0.76	5.02	B3	...	B3 IV	...	*a*	*b*	*c*	*a*
172910*	−0.21	−0.78	4.73	B3	...	B3 V	...	*a*	*a*	*a*	*a*
173117	−0.12	−0.44	5.35	B6	...	B5: V	...	*a*	*b*	*c*	*a*
173375	−0.14	−0.53	6.18	B5	...	...	B6 V	*a*	*b*	*a*	*a*
173948	−0.26	−0.93	3.95	...	...	B1 Ve	...	*b*	*b*	*a*	*c*
175191	−0.21	−0.76	2.08	B3	...	...	B4 IV	*c*	*c*	*a*	*c*
175362*	−0.20	−0.74	5.21	B3	...	B8 IV	...	*a*	*a*	*a*	*a*
175876	−0.30	−1.14	6.41	O6	...	...	...	*c*	...	*b*	*c*
178322	−0.14	−0.52	5.68	B5	...	B5 V	...	*a*	...	*a*	*a*
180885	−0.17	−0.61	5.48	B4	...	B4 IV	...	*a*	...	*a*	*a*
182180	−0.20	−0.74	5.81	B3	...	...	B5 IV	*c*	...	*a*	*b*
183133	−0.18	−0.66	6.33	B3	...	...	B5 V	*c*	...	*c*	*a*
186219	...	...	...	...	...	Am	...	...	*c*	*a*	...
186837	−0.16	−0.58	6.16	B4	...	B5 V	...	*a*	...	*b*	*a*

REMARKS TO TABLE 11

No corrections for duplicity have been applied. Stars with an asterisk are certain members of the association according to Blaauw.

98718 This star could be a member, except for the distance modulus, which is very small; but a duplicity correction of the order of +0.6 mag would take it very near the correct distance modulus.

116072, 116087 They are astrometric companions; 116087 is probably a member; but the motion of 116072 apparently disagrees with membership. This could be due to orbital motion.

122324 Buscombe gives MK type B0.5 I (1963).

138485 Considered as a member by Bertiau, it is below the main sequence in both color-magnitude diagrams; a correction for duplicity would take it further away. Possibly a member, and the position in the diagram is caused by ultraviolet excess.

144844 It has a variable radial velocity, which suggests duplicity; the same remark as for HD 98718 can be made.

154090 Bertiau gives luminosity class I for this star.

167263 Morgan, Whitford, and Code (1955) give O9 II as MK class.

167264 The same authors give MK classification B0 Ia.

TABLE 12

Hβ PHOTOMETRY

HD	β	Distance Modulus β	Distance Modulus Bertiau
72350	2.641	...	...
73390	2.691	6.57	...
74560	2.668	6.78	...
75311	2.577	...	...
76161	2.692	7.26	...
79351	2.650	5.86	...
79447	2.657	6.20	...
80094	2.733	6.58	...
80781	2.666	...	...
81188	2.623	...	...
85980	2.718	6.45	...
86440	2.599	...	...
88206	2.610	...	...
93163	2.656	7.53	...
93194	2.660	6.93	...
93607	2.715	5.68	...
93845	2.687	5.92	...
99264	2.661	7.02	...
102776	2.655	6.55	...
103079	2.718	5.62	5.48
103884	2.692	6.95	6.15
105382	2.674	6.23	5.90
105435	2.460	...	5.90
105937	2.709	4.97	5.60
106490	2.621	5.98	5.81
106983	2.676	5.79	5.48
108257	2.680	6.38	5.65
108483	2.652	6.26	6.11
109026	2.694	5.17	5.38
109668	2.653	5.02	5.84
110335	2.584	...	...
110956	2.705	5.73	5.54
111123	2.597	5.26	5.68
112078	2.682	6.24	6.18
112091	2.578	...	6.30
112092	2.665	6.02	6.30
113703	2.724	6.41	6.00
113791	2.661	6.39	6.88
115823	2.727	6.14	6.30
116087	2.701	5.72	6.51
118716	2.615	5.74	6.83
120307	2.639	6.12	6.26
120324	2.486	...	6.83
120908	2.699	6.72	6.30
120955	2.682	6.33	7.54
121743	2.669	5.74	6.34
121790	2.648	6.30	6.30
122980	2.643	6.82	6.34
123335	2.675	7.51	...
124367	2.556	...	...
124771	2.686	6.46	...
125823	2.646	6.92	5.81
126341	2.605	...	...
126981	2.759	5.69	...
127972	2.553	...	5.40
129056	2.603	6.13	6.78
129116	2.679	5.64	5.84
130807	2.686	5.81	5.94
131120	2.646	7.47	...
132058	2.613	6.14	5.18
132200	2.631	6.06	6.78
132955	2.718	6.16	6.30
133937	2.729	6.50	6.46
133955	2.680	5.68	6.59
134687	2.671	6.69	...
136298	2.616	6.37	6.59
136504	2.659	5.58	...
136664	2.699	5.70	6.59
137432	2.705	6.50	6.04
138485	2.656	7.59	6.34
138690	2.630	5.76	6.59
138764	2.745	5.45	5.97
138769	2.682	6.12	6.38
139160	2.740	6.33	...
139365	2.679	5.34	6.15
140008	2.725	5.49	6.11
141168	2.812	5.25	...
141637	2.644	6.77	6.15
142096	2.713	5.53	6.15
142114	2.676	6.02	6.11
142165	2.724	5.84	6.07
142184	2.655	7.24	6.07
142250	2.732	6.59	...
142378	2.698	6.74	6.22
142669	2.645	6.38	6.18
142990	2.678	6.87	...
143018	2.618	6.01	6.15
143118	2.621	6.62	6.18
143275	2.598	5.88	6.18
143699	2.687	6.33	5.84
144294	2.670	6.10	6.22
144334	2.727	6.39	...
144470	2.623	6.48	6.15
144661	2.696	7.35	...
145482	2.652	6.84	6.22
145502	2.678	4.95	6.11
146001	2.752	5.89	...
146416	2.814	5.89	...
147152	2.704	6.24	...
148184	2.397	...	6.11
148605	2.658	6.76	6.18
148703	2.651	6.51	6.46
149438	2.607	6.42	6.26
149711	2.692	6.74	...
151890	2.626	6.04	6.26
151985	2.621	6.75	6.26
153716	2.703	6.72	...
156325	2.654	...	...
157056	2.628	6.22	6.26
161756	2.666	...	...
168905	2.659	7.40	...
170465	2.714	5.91	...
170523	2.663	...	...
172910	2.683	6.34	...
175362	2.679	6.94	...
178322	2.695	7.05	...
180885	2.675	7.30	...
186837	2.700	7.42	...

REFERENCES

Bertiau, F. C. 1958, *Ap. J.*, **128**, 533.
Blaauw, A. 1946, *Pub. Kapteyn Astr. Lab. Gröningen*, No. 52.
———. 1952, *B.A.N.*, **11**, 414.
———. 1959, *The Hertzsprung-Russell Diagram, I.A.U. Symp. No. 10*, p. 115.
———. 1961, *B.A.N.*, **15**, 265.
———. 1964, *Ann. Rev. Astr. and Ap.*, **2**, 213.
Buscombe, W. 1962, *M.N.R.A.S.*, **124**, 189.
———. 1963, *Mount Stromlo Mimeogram*, No. 7.
Buscombe, W., and Morris, P. 1960, *M.N.R.A.S.*, **121**, 263.
———. 1962, *ibid.*, **123**, 233.
Cousins, A. W. J., and Stoy, R. H. 1963, *R.O.B.*, No. 64.
Crawford, D. L. 1958, *Ap. J.*, **128**, 185.
———. 1964 (private communication).
Feast, M. W., Thackeray, A. D., and Wesselink, A. J. 1954, *Mem. R.A.S.*, **67**, 51.
———. 1957, *ibid.*, **68**, 1.
Graham, J. 1964 (private communication).
Hardie, R. H., and Crawford, D. L. 1961, *Ap. J.*, **133**, 843.
Hiltner, W. A., and Johnson, H. L. 1956, *Ap. J.*, **124**, 367.
Hoof, A. van, Bertiau, F. C., and Deurink, R. 1963, *Ap. J.*, **137**, 824.
Hulst, C. van de. 1949, *Rech. Astr. de l'Obs. d'Utrecht*, **11**, part 2.
Johnson, H. L. 1958, *Lowell Obs. Bull.*, **4**, 37 (No. 90).
———. 1960, *ibid.*, **5**, 17 (No. 2).
Johnson, H. L., and Harris, D. L. 1954, *Ap. J.*, **120**, 196.
Johnson, H. L., and Iriarte, B. 1958, *Lowell Obs. Bull.*, **4**, 47 (No. 91).
Johnson, H. L., and Morgan, W. W. 1953, *Ap. J.*, **117**, 313.
Khavtassi, J. Sh. 1960, *Atlas of Dark Galactic Nebulae* (Abastumani Astrophysical Observatory, U.S.S.R.).
Moreno, H., and Stock, J. 1964, *Pub. A.S.P.*, **76**, 55.
Morgan, H. R. 1952, *Astronomical Papers Prepared for the Use of the American Ephemeris and Nautical Almanac*, **13**, part 3.
Morgan, W. W., Whitford, A. E., and Code, A. D. 1955, *Ap. J. Suppl.*, No. 14.
Morris, P. M. 1961, *M.N.R.A.S.*, **122**, 325.
Oosterhoff, P. Th. 1951, *B.A.N.*, **11**, 299.
Sandage, A. 1957, *Ap. J.*, **125**, 435.
Sharpless, S. 1952, *Ap. J.*, **116**, 251.
Vaucouleurs, A. de. 1957, *M.N.R.A.S.*, **117**, 449.
Whitford, A. E. 1948, *Ap. J.*, **107**, 102.
Wilson, R. E. 1953, *General Catalogue of Stellar Radial Velocities* (Carnegie Inst. of Washington).
Young, A. T. 1963, *Appl. Optics*, **2**, 51.