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VBLUW photometry of the very young open cluster NGC 2264 *

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Abstract. — *VBLUW* photometry of 112 stars with $V < 13$ in the area of the very young cluster NGC 2264, is presented and discussed. Temperatures, gravities and reddening for stars hotter than 8400 K are determined. The reddening and the distance are in good agreement with the results of other references. To the existing list of presumable non-members six stars have been tentatively added as possible non-members.

Key words: open cluster — NGC 2264 — photometry.

1. Introduction.

The very young association NGC 2264 (OCl-495 in Mon OB1) is one of the youngest known associations: the age of the cluster is about 3×10^6 years, as given by the point where the cluster stars depart from the main sequence (Walker 1956) and by fitting the main sequence stars to theoretical isochrones (Mermilliod & Maeder 1986). NGC 2264 is situated at $\alpha = 6$h 40m and $\delta = +9°55'$ (1975.0).

This cluster is probably the most favourable extremely young and open cluster for observing: for the bulk of the stars observations are not contaminated by emission nebulae and NGC 2264 is projected on dark dust clouds (Herbig 1954). The low value for the interstellar reddening of NGC 2264 presents a unique opportunity for the study of early phases of stellar evolution (Rydgren 1979, Pérez *et al.* 1989).

The colour magnitude diagram of earlier observations indicates that the cluster possesses a normal main sequence from 07 to A0. For later spectral types most stars fall above the main sequence (Walker 1956). Walker (1956) argues that the shape of the colour-magnitude diagram agrees approximately with that predicted theoretically for clusters which are so young that the fainter stars are still in the process of contracting gravitationally from the prestellar medium and have not yet reached the main sequence.

A significant fraction of stars with spectral type later than A0 show an infrared excess radiation (Warner *et al.* 1977). Warner *et al.* (1977) found no evidence for extra infrared emission by envelopes with heated dust grains. Observations of several T Tauri stars are reported (Walker 1956; Warner *et al.* 1977). Many of the late-type stars with Hα emission, but not all, show T Tauri features (Rydgren 1979).

Membership probabilities have been derived from relative proper motions (Vasilevskis *et al.* 1965) and a selection criterion has been established for separating most of the field stars from the cluster members (Sanders 1976).

Data from *UBVRI* photometry for 70 stars in the field of NGC 2264 indicate small light variations for a number of stars (Mendoza & Gomez 1980). A slight colour excess in $(V-R)$ points to a small interstellar extinction of $A_{\rm vj} = 0.19$ mag in the line of sight (ibid). The most recent *UBV* photometry has revealed a variable reddening across the cluster (Sagar & Joshi 1983).

The present paper presents and discusses *VBLUW* photometry of 112 stars in the region of NGC 2264 with $V_{\rm j} < 13$, of which 75 presumably members. We derive the distance modulus of the cluster and for a number of stars $T_{\rm eff}$, log g and the interstellar reddening. A comparison is made with previous results.

2. The observations and reductions.

The observations were made in 1985 with the *VBLUW* photometer of Walraven, attached to the 90-cm lightcollector at the ESO, Chile. A description of the photometer and the photometric system has been given by Walraven & Walraven (1960), Rijf *et al.* (1969) and Lub & Pel (1977).

Roughly 110 stars with $V < 13$ in the region of NGC 2264 were measured relative to a number of standard stars of the Walraven system. Most of the stars were measured

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four times. Integration times of half or one minute and a diaphragm aperture of 16.″5 were employed. In the neighbourhood of S Mon, the brightest star of the cluster ($V_j \sim 4.2 - 4.6$), a diaphragm aperture of 11.″6 was employed to avoid contamination due to the high gradient of the sky brightness. Corrections for differential extinction were applied. The standard deviations for the standard stars, which were measured frequently, amount on the average to ± 0.002 in log intensity scale for brightness and colours. For the brightest stars they were somewhat smaller, for the fainter stars somewhat larger. As is the normal practice, brightness and colours in the *VLBUW* system are expressed in terms of the logarithm of the intensity.

The brightness V and the colour index $(V - B)$ of the *VBLUW* system can be transformed into the V and $(B - V)$ (both with subscript J), respectively, of the Johnson *UBV* system with the aid of Pel's (1986) formulae:

$$V_j = 6.886 - 2.5[V + 0.030(V - B)]$$
$$(B - V)_j = 2.571(V - B) - 1.020(V - B)^2 + $$
$$+ 0.500(V - B)^3 - 0.010$$

The first formula is practically independent of reddening and can be used for stars earlier than spectral type M. The second formula can be applied to stars bluer than $(B-V)_j \sim 1.5$ and with not too much reddening, with an accuracy $< 0^m01$.

Table 1 lists the average photometric parameters of the stars in the *VBLUW* and *UBV* photometric systems. The standard deviations in the brightness and colours amount to ± 0.003 and ± 0.002 in log intensity, respectively, for the bulk of the stars but are twice as large for the faintest stars.

The average difference between our values for V_j and $(B - V)_j$ and those of other references (results of this work minus those of other investigations), are listed in table II together with standard deviations and mean errors.

3. The determination of log g, $T_{\rm eff}$ and the reddening.

Figure 1 shows the observed position of the members (dots) and non-members (dots with bars) of NGC 2264 in the $(V - B)/(B - U)$ diagram (see section 4 for more suspected non-members). The main sequence, the reddening line (represented by an arrow) and the Walker numbers are indicated. In the right top corner the red extension of the main sequence is shown separately. Notice that here the scales are reduced by a factor two. In the left top corner the error bars are indicated, representing the average standard deviation in $(V - B)$ and $(B - U)$, respectively. Stars no. 27, 33, 83, 108, 125, 151 show a larger error in $(V - B)$ and/or $(B - U)$ and are probably variable (Warner *et al.* 1977; Sagar & Joshi 1983). Some of these stars are identified as spectroscopic binaries (Mermilliod 1976; Mendoza & Gomez 1980). Stars no. 17, 26, 60, 66, 68, 121, 154, 208, 221 and 234 may also be variable.

The width of the band occupied by the stars exceeds the average errors in the colour indices, indicated by the error bars in Figure 1. This can be partly explained by the effect of non-uniform extinction. Evidence for extensive differential reddening has been established in NGC 2264 by intermediate dispersion spectra and broadband photometry. The source of this reddening are evidently intracluster dust clouds, which are not randomly distributed within the cluster (Young 1978). A detailed discusion of the differential extinction in clusters and its treatment can be found elsewhere (Burki 1975; Sagar 1985). Another explanation for the scatter in the main sequence is the possibility of small differences in gravity. This is plausible, because evidences for non-coeval star formation in NGC 2264 are found (Sagar 1985).

The gravities of 32 of the observed stars, mainly belonging to the upper part of the main sequence, have been determined with the aid of two extinction independent theoretical two-colour diagrams: $[B-U]/[B-L]$ and $[B-U]/[U-W]$. These diagrams were computed by Lub and Pel(1984), based on the model atmospheres of Kurucz (1979) for solar abundances and a micro turbulence velocity of $v = 2$ km/s. Estimated mean errors in log g range from ± 0.1 up to ± 0.5 dex for the cool and the hot stars, respectively. For the same stars values for $T_{\rm eff}$ were also read off in both diagrams in the range of 8000 to 30000 K. The accuracy amounts to ± 200 K for the cooler stars and ± 2000 K for the hot stars.

Temperatures and gravities are listed in Table 1. For most of the stars these values derived from both diagrams were consistent within the observational errors. No reliable values for $T_{\rm eff}$ and log g could be determined for the stars with $T_{\rm eff} < 8000$ K. The reasons are crowding effects of the theoretical lines for constant $T_{\rm eff}$ and constant log g and the incompleteness of the theoretical grids.

The width of the main sequence band in Figure 1 must be also partly caused by differential reddening. Sagar (1985) suggested a differential reddening of the order of $\pm 0^m1$. He derived the reddening for 140 stars with the aid of *UBV*-photometric data. In order to find the reddening for each of the sample discussed above they were shifted along the reddening path onto the appropriate log g line in the theoretical $V - B/B - U$, $V - B/U - W$ and $V - B/B - L$ diagrams. For each star the values for the reddening, found in these diagrams, were averaged with weights according to the accuracy of the observational data in the various bandpasses. These values are listed in Table 1. $E(V - B)$ can be transformed into $E(B - V)_j$ with the aid of the relation $E(B-V)_j = E(V-B)\,\{2.39 - 0.17\,E(V-B)\}$ (Pel 1986).

For star no. 142 the values for log g do not agree very well in both reddening-independent colour diagrams. However, in the theoretical $V-B/B-U$ diagram the log g lines for log $g > 3.5$ and for $T_{\rm eff} > 10000$ K practically coincide. So we shifted the star to the main sequence (log $g = 4-4.5$) to determine its reddening.

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The average reddening for the whole cluster based on this small sample including the dubious members, but excluding star 202, because it is likely a background star, amounts to $E(V-B) = 0.018$ or $E(B-V)_j = 0.042$ and is listed in Table 3, together with the determinations from Walker (1956) and Sagar & Joshi (1983). Perhaps due to the rigorous selection of stars, we find a lower reddening (by a factor of two) than the two sources just mentioned.

4. The distance, the HR diagram and the age.

Each star in the $V_0/(V-B)_0$ diagram represented in Figure 2 for presumable members has been corrected for the interstellar reddening, determined in section 3. We thus omitted the 28 foreground and 3 background stars, which were already suspected as such in literature (see Tab. 1). Some other stars may be also non-members in view of their positions in Figures 1 and 2, such as 13, 37, 38, 177, 220 and 239 (underlined in Figure 2). With the exception of star 37, they also lie outside the central portion of the cluster (see also Walker 1956).

Because it is unknown which extinction law is valid in the region of NGC 2264, for each star V is corrected to V_0 using the formula for the ratio of total to selective extinction in the *VBLUW* system (Pel 1986):

$$R = A_v/E(V-B) = 3.16 - 0.12 \times E(V-B)$$

with $E(V-B)$ the average reddening in the direction of the cluster. The exceptions are stars 100 and 215, which were corrected with their individual reddenings, because these values are much larger than the average cluster reddening.

A number of stars were not used for the distance determination of the cluster. Star 103 and 187 are visual double stars (Walker 1956), and star 50, 74 and 187 show some double lines in their optical spectra (Walker 1956). Star 132 and 157 may be variable stars (Warner *et al.* 1977). All these stars and the presumable non-members are excluded from the distance determination. Of the remaining stars log $T_{\rm eff}$, if known has been plotted against V_0 and shifted towards the M_{vj} – log $T_{\rm eff}$ relation. This diagram is based on the ZAMS table of Schmidt-Kaler (1982). For main sequence stars hotter than the Sun, $T_{\rm eff}$ is strongly correlated with the unreddened $(B-V)_j$ (Flower 1977; Böhm-Vitense 1981). Fitting the remaining 15 stars to the ZAMS of the *VBLUW*-system (Thé *et al.* 1980) gives the distance modulus:

$$(m-M)_0 = 3.67 \pm 0.04 \text{ (log intensity scale)}$$
$$9.2 \pm 0.1 \text{ (mag scale)}$$

This corresponds to a distance of 700 ± 40 pc. The distance modulus in mag is estimated with the aid of the relations for the *UBV*-mag scale (Claria & Rosenzweig 1978). The V_0 and $(V-B)_0$ were transformed into V_{jo} (and with the aid of the distance modulus into M_{vj}) and $(B-V)_{jo}$ using the formulae, given in section 2. M_{vj} and $(B-V)_{jo}$ are listed in Table 4. For presumable non-members M_{vj} is omitted, with the exception of the six stars mentioned at the beginning of this section, which are tentatively classified as non-members.

Many distance determinations have been made in the past, varying between 150 pc (Charlier 1918) and 1000 pc (Georgelin 1970). Our distance agrees very well with the distance of 715 pc, derived by Becker (1971) and with the distance of 724 pc, derived by Karlsson (1972). The most recent distance determination based on *UBV* photometric data yielded a distance of 790 pc (Sagar & Joshi 1983).

NGC 2264 belongs to the age group of NGC 6231 (Mermilliod 1981a,b). An age for this group of - 3×10^6 yr has been derived (Mermilliod & Maeder 1986) and for the evolved members of NGC 6231 alone, an age of 3.6 $(\pm 0.6) \times 10^6$ yr was found (van Genderen *et al.* 1984). The age of the stars in NGC 2264 still to the right of the main sequence are apparently smaller than 3×10^6 yr. A more precise age determination for these pre-main sequence stars is not yet possible.

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TABLE 1. *Photometric results of the stars into the direction of NGC 2264. VBLUW system in log intensity scale, UBV system with subscript J in mag scale. For part of them also the reddening, temperature and gravity is listed.*

STAR	V	V-B	B-U	U-W	B-L	E(V-B)	V_J	$(B-V)_J$	Teff	log g	Spectral type (and reference)	Remarks
2	-1.1336	.0966	.4605	.1740	.2110		9.71	.23			A7 III IV 1)	
6	-.5341	.1524	.3240	.1633	.1902		8.21	.36				1)
7	-.3580	-.0440	.1133	.0069	.0438	.017	7.78	-.13	16700	4.3		
9	-2.0839	.9411	.9986	.3545	.8396		12.02	1.92				1)
10	-1.7669	.2457	.4582	.2268	.2503		11.28	.57				
13	-2.0977	.7627	.7607	.2222	.6246		12.07	1.58				
17	-2.4022	.1736	.4953	.1690	.2348		12.88	.41				
20	-1.3826	.1782	.4224	.2121	.2245		10.33	.42			F2 III 1)2)	2)
24	-.6832	-.0230	.2652	.0633	.0821	.013	8.60	-.07	12200	3.8		
25	-.3827	.1562	.3507	.1754	.2101		7.83	.37				1)
26	-1.9653	.2071	.3145	.1753	.2082		11.78	.48				
27	-2.0887	.2215	.5144	.2225	.1934		12.09	.51			A0 III 1)	9)
28	-2.1809	.1906	.2988	.1622	.1946		12.32	.45				
29	-1.3324	.1767	.3669	.1999	.2187		10.20	.42				
30	-1.5519	.0135	.4201	.0944	.1823		10.76	.02			A0 V 3)	3)
31	-1.3506	.1381	.3599	.1677	.1916		10.25	.33			A7 IV 1)	4)
32	-2.4040	.3569	.6732	.2376	.2918		12.87	.80				
33	-1.9833	1.1442	.9704	.5680	1.0065		11.75	2.35			K1 V 3)	5)6)
34	-1.6489	.1656	.3919	.1846	.2107		10.99	.39				
35	-1.3785	.0326	.4259	.1092	.1911		10.33	.07				
36	-1.6562	.0133	.4136	.0902	.1797		11.03	.02			B9 2) B9 V 3)	3)6)
37	-.5007	.6672	.8387	.5189	.7528		8.08	1.40			K5 III 1)	
38	-1.6752	.4527	.6168	.4033	.3083		11.04	.99				
39	-1.7964	.0546	.4403	.1278	.2088		11.37	.13				
43	-1.4833	.0836	.4636	.1629	.2077		10.59	.20			A7 III 1) A7 2) A7 V 3)	8)
46	-.9437	.0891	.4826	.1797	.1943		9.24	.21			A5 III 1) A5 2) A3 V 3)	7)8)
50	-.5054	-.0503	.0758	-.0022	.0336	.019	8.15	-.14	18500	4.4	B3 V 1) B2.5 V 2) B3 V 3)	
60	-2.2651	.4494	.7537	.5046	.3118		12.51	.98				
65	-1.9769	.1814	.3201	.1706	.1904		11.81	.43				
66	-2.2546	.3188	.2901	.1347	.1797		12.50	.72			A0 V 3)	
67	-1.6376	.2523	.1824	.0950	.1146		10.96	.58			B2 V 1)3)	9)
68	-1.9671	.2786	.3511	.2305	.2521		11.78	.64			G0 IV/V 1)2) F4 V 3)	
69	-.5873	.6415	.7891	.5143	.7179		8.30	1.35			K3 II-III 1)	15)
70	-1.7318	.2414	.3222	.2009	.2498		11.20	.56				15)
73	-1.0155	.3668	.4780	.2686	.3822		9.39	.82			G5 III 1)2)	4)10)15)
74	-.6450	-.0420	.1162	.0096	.0506	.017	8.50	-.12	16600	4.3		11)15)
83	-.4291	-.0590	.0218	-.0139	.0099	.021	7.96	-.17	21900	4.5	B2 IV 2) B2 V 3)	6)8)
87	-1.5736	.0884	.4760	.1655	.1953		10.81	.21				
88	-.8781	-.0345	.0105	.0066	.0438	.028	9.08	-.10	17400	4.4	B3 V 1)2) B5 V 3)	8)12)
91	-2.2218	.2677	.2977	.2439	.2475		12.42	.61				
92	-1.9472	.3771	.4199	.2275	.3631		11.72	.84			K0 IVp 1)	15)
94	-1.4545	.1690	.3168	.1756	.1972		10.51	.40				
98	-1.9901	.2242	.3389	.1916	.2464		11.84	.52				
99	-1.6056	.1856	.3091	.1736	.2038		10.88	.44				15)
100	-1.2694	.0534	.4545	.1442	.1771	.050	10.06	.12	9500	3.8	A2 IV 1) A0-A2 2) B8 V 3)	7)8)12)13
103	-1.2891	.0052	.3685	.0820	.1554	.017	10.11	.00	10500	4.5		14)
104	-1.8193	.0958	.4204	.1518	.2055		11.43	.23			A5 IV 1) F0-A5 2) A5 IV 3)	8)
107	-.7957	-.0234	.2069	.0324	.0826	.021	8.88	-.07	13700	4.4		
108	-2.0931	.2635	.3472	.2550	.2452		12.10	.61			G0 III,IV 1)2) F7 V 3)	4)7)8)13)
109	-.9042	-.0408	.1494	.0152	.0562	.013	9.15	-.12	15300	4.3	B6 V 1)2) B3 V 3)	8)12)
112	-1.5796	-.0007	.3550	.0723	.1410	.016	10.84	-.01	10700	4.5	A0 V 1)3) A0 2)	8)
114	-1.8951	.2173	.3566	.2095	.2267		11.61	.51				
116	-1.9251	.2222	.3373	.2019	.2206		11.68	.52			F5 III,IV 1) F7 V 3)	
118	-1.9748	.2379	.3326	.1999	.2205		11.80	.55				
121	-2.2413	.3522	.3091	.1104	.2744		12.46	.79			F8 V 3)	
125	-2.1928	.2575	.3226	.2201	.2488		12.35	.59			F6-G0 III-Vp 1) F6-G0 2) F9 V 3)	6)8)
128	-1.6704	.1222	.4009	.1659	.2134		11.05	.29				
132	-1.3412	-.0155	.2761	.0497	.1063	.017	10.24	-.05	12100	4.5	B8 V 3)	8)13)
134	-2.3256	.4031	.3828	.1731	.3324		12.67	.89			G5 V 3)	6)
137	-1.2230	-.0298	.2328	.0348	.0911	.009	9.95	-.09	12900	4.5	B8 V 2) B5 V 3)	8)
138	-1.3378	.0258	.4062	.0986	.1787	.025	10.23	.06	9800	4.4	B9 2) A0 V 3)	8)
142	-.7891	-.0306	.1818	.0377	.0749	.018	8.86	-.09	14200	4.5	B6 V 3)	8)14)
145	-1.5210	.0239	.4241	.0987	.1801		10.69	.05			A0 V 1) A0 2) A0 V 3)	6)8)
147	-1.6691	.3563	.4427	.2517	.3933		11.03	.80				1)
151	-2.2926	.2138	.3176	.1976	.2232		12.60	.50			G2 2) F5 V 3)	6)8)
152	-.9075	-.0250	.2343	.0439	.0825	.016	9.16	-.07	12900	4.2		15)
154	-2.3639	.2992	.3426	.2101	.2683		12.77	.68			G2 III,IVp 1)2) G2 V 3)	
157	-1.2844	-.0216	.2603	.0539	.0933	.014	10.10	-.07	12400	4.2	B8 V 3)	8)13)
158	-1.4020	.1560	.4296	.1907	.2139		10.38	.37			A7-F0 IV,Vp 1) A5-F0 2) F0 V 3)	7)8)
159	-1.6434	.0231	.3939	.0939	.1756	.024	10.99	.05	10100	4.5	A0 V 1)3)	8)
165	-1.6558	.0633	.4369	.1253	.2081	.010	11.02	15	8400	4.2	A2 V 3)	7)8)
170	-1.2957	-.0252	.2223	.0393	.0802		10.13	- 08				
172	-1.2911	-.0312	.2227	.0408	.0856	.007	10.12	-.09	13100	4.2		
177	-1.0067	.2640	.3291	.2194	.2772		9.38	.61				
178	-.1273	-.0741	-.0365	-.0283	-.0212	.016	7.21	-.21	25900	4.2	B1.5 2)	15)
179	-1.2261	-.0067	.3426	.0744	.1310	.014	9.95	-.03	10900	4.4	B9.5 V 2) B9 V 3)	8)12)
180	-2.4495	.2211	.3040	.1963	.2164		12.99	.51				15)
181	-1.3019	-.0205	.2854	.0703	.0971	.012	10.14	-.06	11800	3.9	B9-A0 IV-V 1) B9-A0 V 2) B9 V 3)	
182	-1.3840	.0242	.4385	.1089	.1906	.000	10.34	.05	8900	4.1	A2 V 1)	
187	-.9444	-.0254	.2495	.0491	.0907	.013	9.25	-.08	12600	4.2	B8 V 2)3)	8)12)13
189	-1.8223	.2322	.3398	.1949	.2274		11.42	.54			F5 2) F2 V 3)	13)
190	-2.1921	.2700	.3355	.2051	.2540		12.34	.62			G2-G5 2) G0 V 3)	13)
193	-1.1850	.0971	.4285	.1554	.2134		9.84	.23			A7 IIIp 1)	15)
195	-2.3348	.2268	.3126	.1849	.2254		12.70	.53				15)
196	-1.8749	.2250	.2909	.1905	.2127		11.55	.52			F6-F8 IV 1)	4)15)
202	-.8501	.0371	.0865	.0310	.0481	.080	9.01	.08	21500	4.5		9)
203	-2.4518	.2691	.2759	.2301	.2439		12.99	.62				15)
205	-1.5214	.1411	.3532	.1599	.1956		10.68	.33				15)
206	-.7440	-.0336	.2116	.0281	.0809	.010	8.75	-.10	13400	4.4	B7 V 2) B8 V 3)	8)14)
208	-2.3141	.3247	.3545	.2148	.2839		12.64	.73				
209	-1.7927	.1535	.3421	.1702	.2014		11.36	.36			F2 2) F2 V 3)	8)
212	-.2542	-.0593	.0616	-.0096	.0246	.013	7.53	-.17	19200	4.5	B2.5 V 1) B2 IV 2) B3 V 3)	8)
215	-.9865	.0267	.3391	.0869	.1446	.054	9.35	.06	11400	4.4	A0 IV-V 1) B9-A0 2) A0 V 3)	14)
216	-2.0257	.3155	.3717	.2206	.3292		11.92	.72				15)
220	-1.1567	.1979	.3111	.1812	.2157		9.76	.46				
221	-2.1293	.1715	.3198	.1677	.1915		12.20	.40				
222	-1.2212	.0509	.4756	.1462	.1986	.014	9.93	.12	8400	3.7	A3 IV 1) A3 2) A2 V 3)	6)8)
223	-1.6288	.1370	.3698	.1654	.1956		10.95	.32				15)
224	-1.8883	.2731	.3408	.2121	.2943		11.58	.63			F5 V 3)	13)
226	-1.1076	.0589	.4700	.1500	.2105		9.65	.14			A3-4 III 1)	15)
227	-1.9981	.2181	.2905	.1994	.2055		11.86	.51				
228	-1.7133	.1538	.3492	.1732	.2030		11.16	.36			F2 2) F0 V 3)	8)13)
229	-.6900	.5299	.6510	.4076	.5997		8.57	1.14			K2 II-III 1)2)	10)
230	-2.2633	.4048	.4676	.2894	.4274		12.51	.90			K0 V 3)	6)
231	-.8441	-.0480	.1021	.0077	.0369	.014	9.00	-.14	17200	4.2	B5 V 2)3)	
232	-1.1995	.0017	.4118	.1013	.1508	.009	9.88	-.01	9800	4.1		
233	-1.0881	.2447	.3297	.2140	.2586		9.59	.57			G0 V 1)	1)
234	-2.2433	.1889	.3346	.1813	.2146		12.48	.44				
236	-1.8312	.2691	.3371	.2278	.2812		11.44	.62				15)
237	-1.0442	.6276	.6860	.4333	.6034		9.45	1.33			K2 II-III 1)2)	10)
238	-1.2691	.5873	.7767	.5476	.6788		10.01	1.25				10)
239	-1.0343	.5256	.6473	.4186	.5877		9.43	1.13				10)

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References to Table 1 :

1) Walker (1956)
2) Warner *et al.* (1977)
3) Sagar & Joshi (1983)

Remarks to Table 1 :

1) (probabably) foreground star (Walker 1956)
2) variable (Warner *et al.* 1977)
3) spectroscopic binary (Sagar & Joshi 1983)
4) peculiar? (Walker 1956)
5) probably field star (Walker 1956; Sagar & Joshi 1983)
6) probably variable (Sagar & Joshi 1983)
7) Hα emission star (Young 1978)
8) spectroscopic binary or variable radial velocity stars (Mermilliod 1976; Mendoza & Gomez 1980)
9) (probably) background star (Walker 1956)
10) (probably) field star (Warner *et al.* 1977)
11) spectroscopic binary (Walker 1956)
12) (probably) variable velocity (Walker 1956)
13) probably variable (Warner *et al.* 1977)
14) visual double star (Walker 1956; Sagar & Joshi 1983)
15) membership probability $< 50\%$ (Vasilevskis *et al.* 1965; Sanders 1976)

TABLE 2. *The differences of magnitudes V_J and colours $(B-V)_J$ between those based on this and other work.*

	Walker (1956)	Mermilliod (1976)	Warner et al (1977)	Mendoza/Gómez (1980)	Sagar/Joshi (1983)
ΔVj	.037	.052	.011	-.008	-.025
σ	.093	.179	.079	.080	.088
σ/√n	.009	.017	.012	.011	.013
Δ(B-V)j	-.037	-.031	-.043	-.006	-.018
σ	.062	.084	.045	.033	.036
σ/√n	.006	.008	.007	.004	.005
n	107	110	43	53	46

TABLE 3. *A comparison between a few average cluster reddenings $E(B-V)_J$ based on various sources.*

Reference	E(B-V)J σ σ/√n
Walker (1956)	0.082
Sagar and Joshi (1983)	0.095 0.092 0.008
This paper	0.042 0.048 0.009

TABLE 4. *Intrinsic colours $(B-V)_J$ and absolute magnitudes M_{VJ}. Most of the listed stars are members (see section 4).*

Walker No	(B-V)JO	MVJ	Walker No	(B-V)JO	MVJ
2	.19	.35	128	.25	1.69
6	.32		132	-.09	.88
7	-.17	-1.58	134	.86	3.30
9	1.89		137	-.13	.58
10	.53	1.92	138	.02	.86
13	1.55	2.70	142	-.13	-.50
17	.37	3.51	145	.01	1.32
20	.38	.96	147	.77	
24	-.11	-.77	151	.46	3.23
25	.33		152	-.12	
26	.45	2.42	154	.65	3.41
27	.48		157	-.11	.73
28	.41	2.96	158	.33	1.01
29	.38	.84	159	.01	1.63
30	-.02	1.40	165	.11	1.66
31	.29	.89	170	-.12	.76
32	.77	3.50	172	-.13	.75
33	2.31		177	.57	.02
34	.35	1.63	178	-.25	
35	.03	.96	179	-.07	.59
36	-.02	1.66	180	.48	
37	1.37	-1.28	181	-.11	.78
38	.96	1.67	182	.01	.98
39	.09	2.01	187	-.12	-.12
43	.16	1.22	189	.50	2.06
46	.17	-.13	190	.59	2.98
50	-.19	-1.21	193	.19	
60	.95	3.15	195	.49	
65	.39	2.45	196	.49	
66	.69	3.13	202	-.11	
67	.55		203	.58	
68	.60	2.42	205	.30	
69	1.32		206	-.14	-.62
70	.52		208	.70	3.28
73	.79		209	.33	1.99
74	-.16		212	-.21	-1.84
83	-.21	-1.40	215	-.07	-.32
87	.17	1.45	216	.68	
88	-.14	-.28	220	.43	.40
91	.58	3.05	221	.37	2.83
92	.81		222	.08	.57
94	.36	1.14	223	.29	
98	.49	2.48	224	.59	2.22
99	.40		226	.10	
100	.00	.42	227	.47	2.50
103	-.04	.74	228	.33	1.79
104	.19	2.06	229	1.11	
107	-.11	-.49	230	.86	3.15
108	.57	2.73	231	-.18	-.36
109	-.16	-.22	232	-.05	.52
112	-.05	1.47	233	.53	
114	.47	2.24	234	.41	3.11
116	.48	2.32	236	.58	
118	.52	2.44	237	1.30	
121	.76	3.10	238	1.22	
125	.56	2.98	239	1.10	

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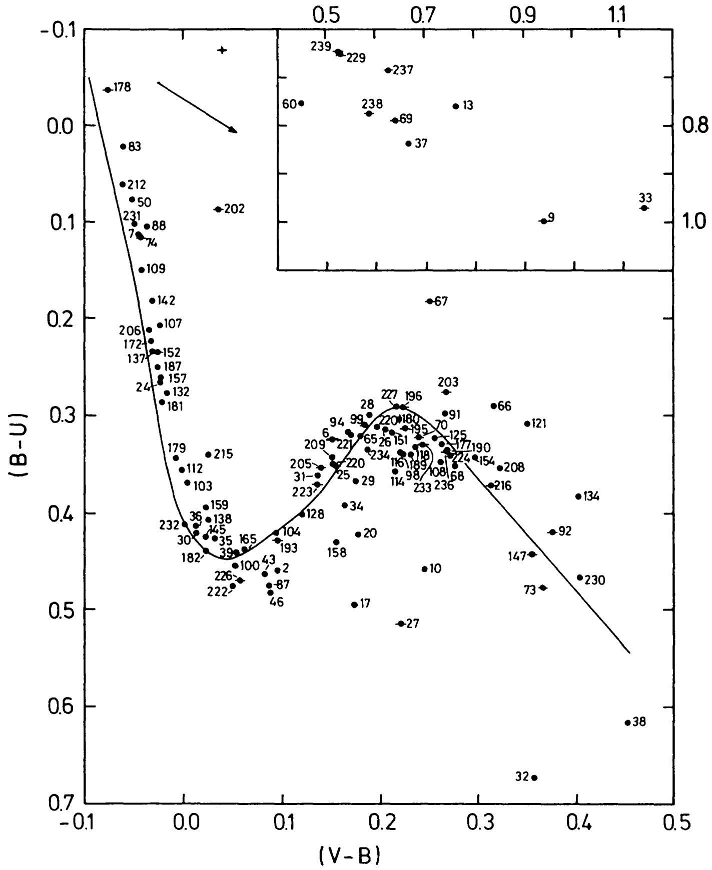

FIGURE 1. $V-B/B-U$ diagram (log intensity scale) with the observed position of the stars in the area of NGC 2264. The main sequence and the reddening trajectory (arrow) are shown. The cross at the left top indicates the average errors in the colours for the bulk of the stars, but are expected to be twice as large for the faintest stars. Stars with membership probability smaller than 50% (according to Vasilevskis *et al.* 1965; Sanders 1976) are indicated with a bar, but more stars are doubtful members (section 4 and Fig. 2).

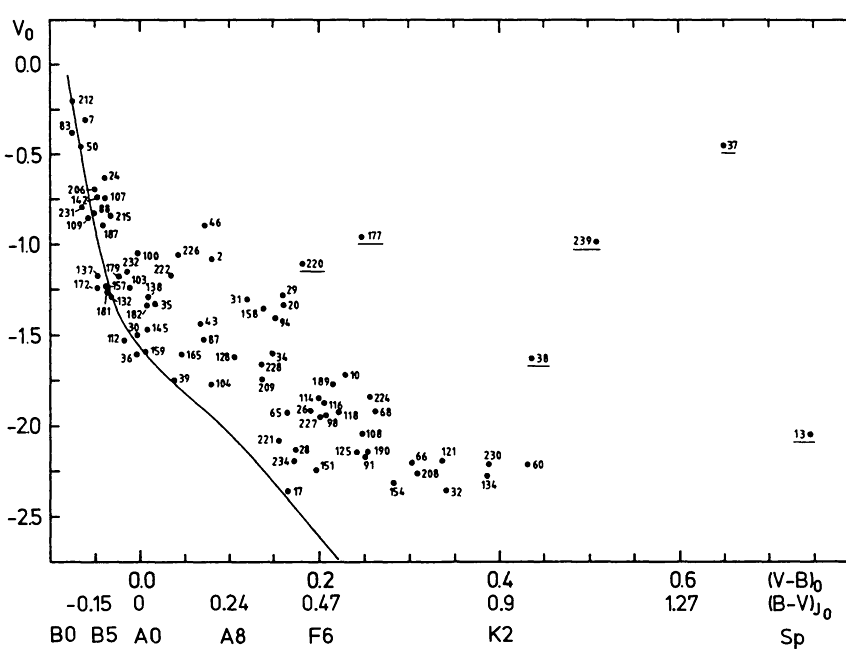

FIGURE 2. The $V_0/(V-B)_0$ diagram (in the Walraven system) of NGC 2264. As a comparison the $(B-V)_{J_0}$ scale is added, as well as the spectral sequence. The ZAMS of Thé *et al.* (1980) is shown. Stars which are according to the literature presumably non-members are omitted, while the underlined objects may be also non-members (Sect. 4).

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