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VBLUW photometry of the stars and nebulosity of N 70 in the LMC*

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Summary. We give photometric *VBLUW* data for the stars and nebulosity of N 70 in the LMC. The data for the central cluster stars, an OB association mainly of main sequence stars, confirm earlier colour determinations and spectral types. Located in the direction of the shell region of the nebula we find a number of supergiants which may partly be associated with N 70. The photometry for three of these stars give extinctions of $A_{V_J} \sim 3^{\mathrm{m}}$. Also found for a few stars in other nebulae of the LMC, this amount of extinction – if of interstellar origin – does not agree with the interstellar gas to dust ratio of the LMC. The extinction may be produced in circumstellar dust shells.

Key words: photometry – stars and emission nebula (LMC) – extinction

1. Introduction

The ring-shaped nebula of N 70 in the LMC (Henize's Catalog, 1956), its internal cluster (see Fig. 1), the emission line ratios of the gas, and the radio observations have led to various identifications: SNR, H II region, emission nebula produced by stellar winds interacting with a collapsing H I cloud (cf. Lasker, 1976, 1977, 1981; Danziger and Dennefeld, 1976; Meaburn, 1978; Blades et al., 1980; Rosado et al., 1980; Dopita et al., 1981 – see this paper also for radio observations). Mainly the stars of the central cluster have been investigated so far (Lucke, 1972; Rosado et al., 1981). We have extended the observations and give *VBLUW* photometric data of stars (with $V_J \lesssim 15^{\mathrm{m}}$) located inside the shell region of the nebula.

The stars associated with N 70, or located in the region of this object, appear more or less strongly embedded in nebulosity. Photometric observations of the stars hence may be effected by nebular emission. We use *VBLUW* photometric data of the nebula to correct, where necessary, the stellar observations in order to derive intrinsic colours of the stars.

We give in Sect. 2 the photometric data; in Sect. 3 we discuss the observations of the stars.

2. Observations and reductions

The observations were made in December 1980, January 1982 and December 1983, with the Walraven *VBLUW* photometer attached to the 90-cm Dutch Telescope at ESO, La Silla, Chile. A description of the photometer and the photometric system is given by Walraven and Walraven (1960), Rijf et al. (1969), and Lub and Pel (1977). We transformed the observations to the photometric system used in the years 1970–1978 (cf. Greve and van Genderen, 1982a). For the *UBV* system we use the subscript *J*. The visual apparent magnitude V_J (Tables 1, 3) is obtained from the relation (Pel, 1976)

$$V_J = 6.874 - 2.5\,[V + 0.065\,(V-B)]\,. \tag{1}$$

For the nebula, V_J is the surface brightness of the area inside the diaphragm, i.e. 200 arcsec^2.

We show in Figs. 1a and 1b the observed stars and nebulosities; the corresponding photometric data are given in Tables 1 and 3, respectively. The positioning accuracy of the telescope was $\sim 5''$ and the positions of faint stars were checked by off-set measurements against bright stars. Only those stars were observed which could be located and identified by visual inspection through the eyepiece. The observations were made through a circular diaphragm of 16″ diameter; the integration time for stellar and nebular measurements was typically ~60 s and ~400 s, respectively. The sky background is subtracted from the data of Tables 1 and 3. Lasker (1981) estimates negligible reddening in the direction of N 70; Dopita et al. (1981) used $A_{V_J} = 0.6^{\mathrm{m}}$, which in the *VBLUW* system is $A_V = 0.25$, $E(V-B) = 0.08$, $E(B-L) \simeq E(U-W) = 0.03$, $E(B-U) = 0.05$. The data of Tables 1 and 3 are *not* corrected for reddening.

In view of the results of the first observations (in 1980) and the comments of the referee, we observed in 1983 all stars of the north-eastern shell region visible in the eyepiece ($V_J \lesssim 15^{\mathrm{m}}$) under good seeing conditions. For some observations there may have been two stars in the diaphragm; this may be the case for "stars" 14, 16, 28, 31, and 32 (see Fig. 1a). Since we cannot separate the individual stars, Tables 1 and 2 give the combined colours and brightnesses. However, from the combined colour indices we deduce that the individual components are blue stars. Because of the very low brightness ($V_J \lesssim 17^{\mathrm{m}}$) of the central nebulosity, stars of similar or fainter brightness visible in the region of N 70 (see Fig. 1a) may have disturbed these observations.

N 70 contains the cluster LH 114 (Lucke and Hodge, 1979; Lucke, 1972). In the vicinity of the cluster stars 1–12 we measured

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* Based on observations collected at ESO, La Silla, Chile

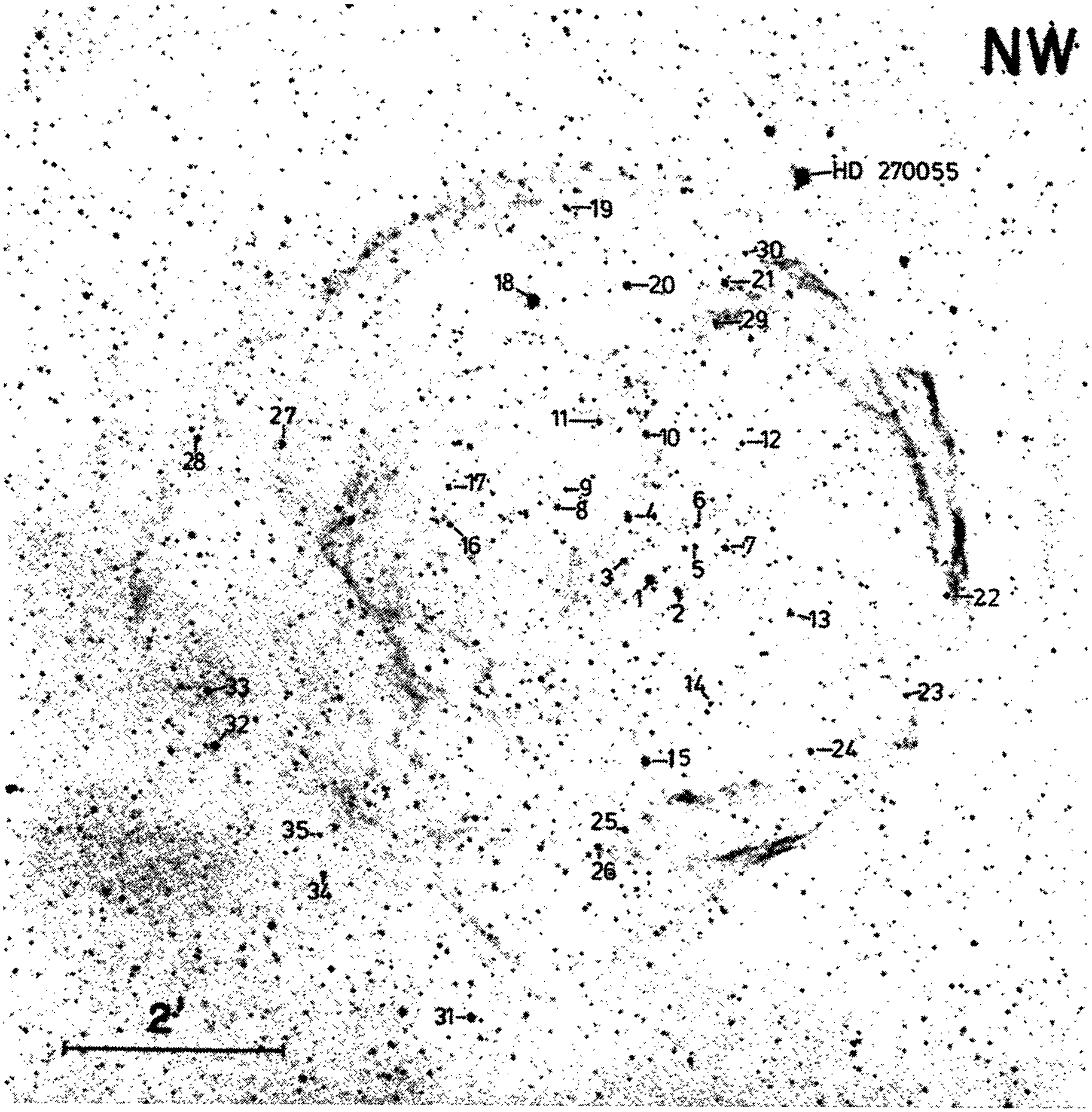

Fig. 1a. N 70 (taken from Lasker, 1977) and indication of observed stars (see Tables 1 and 2)

the nebulosity (Fig. 1b). The photometric data of the cluster stars as given in Tables 1 and 2 are corrected for the corresponding nearby nebular emission (Table 3) taken as local backgrounds. Although this procedure may be questioned, the corrections do not exceed $\Delta V_J \sim 0.1^{\mathrm{m}}$, i.e. $\Delta V \sim 0.04$, $\Delta(V-B) \sim \ldots \Delta(U-W) \sim 0.03$. To illustrate the influence of the nebular backgrounds we have taken the data of star 8(OB V), with negligible reddening $A_{V_J}=0.08^{\mathrm{m}}$, and added according to the equations of the photometric system (Greve and van Genderen, 1982b) the *brightest* nebular emission measured at position 4 (see Fig. 1b). The combined colours, shown in Fig. 2, exhibit only small deviations from the corrected stellar colours.

In Table 1 we also give the photometric data of the cluster stars determined by Lucke (1972) and Rosado et al. (1981). We find consistency, in particular with the data by Lucke.

3. The stars, the extinction A_{V_J} and the intensity of the nebular emission

3.1. *The stars*

We determined the extinctions A_{V_J} based on a tentative spectral classification with the aid of the colour diagrams (CD) shown in Fig. 2; the corresponding data are given in Table 2. M_V is

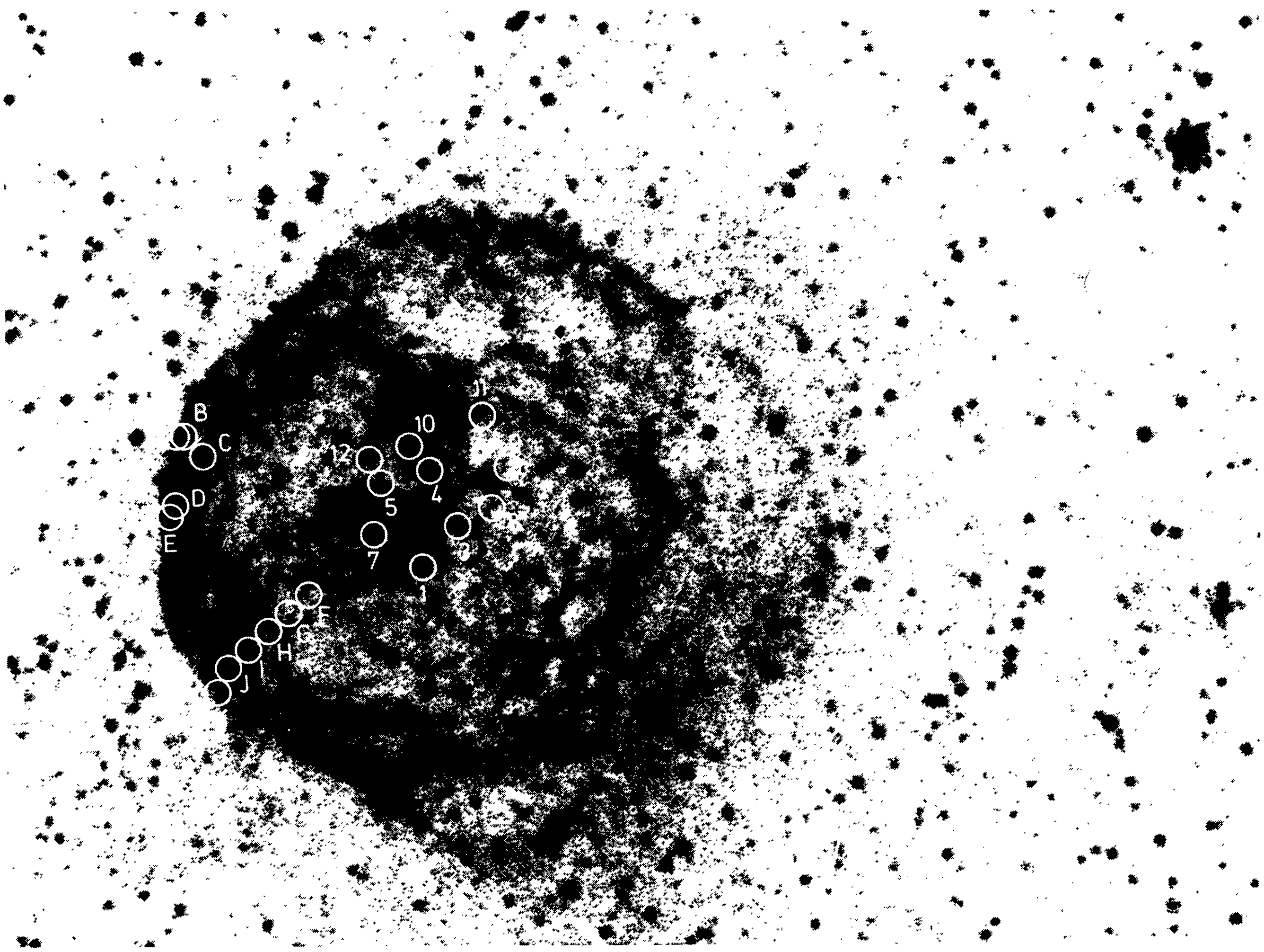

Fig. 1b. N 70 and indication of observed nebulosities (see Table 3). Circles indicate the 16″ diameter (~4 pc at the distance of the LMC) of the diaphragm

calculated for $(m-M)_{\rm LMC}=18.6$. From the empirical values $E(V-B)$ we calculated $E(B-V)_J=2.57\,E(V-B)$ for OB stars, $E(B-V)_J=2.3\,E(V-B)$ for FG supergiants (Lub, 1980; Pel, 1981); $A_{V_J}=3.1\,E(V-B)_J$.

V_J and the colours (Table 1, Fig. 2) indicate that the stars 15 and 34 are most probably galactic FV field stars and 21 probably a G0V star (see below). HD 270055 is a galactic K(II–V) field star. The positions in the CD (Fig. 2) and the HR diagram (Fig. 3) exclude a galactic membership of the other stars. This membership is substantiated by the fact that for most of the stars the derived values $E(B-V)_J$ are larger than the foreground reddening $E(B-V)_J \simeq 0.05^{\rm m}$ derived by Walraven and Walraven (1971), Isserstedt (1971), and Brunet (1975).

The cluster stars 1–12 are distinctly shown in Figs. 2 and 3 by dots; star 13 may also be a member of the cluster. In the HR diagram (Fig. 3) we also show the isochronous curves based on normal points for the very young galactic cluster groups NGC 2362 and NGC 6231 as determined by Mermilliod (1981a, b). In this comparison of the LMC cluster and the galactic clusters the difference in the abundance is of little influence for OB stars. According to Mermilliod (1981a), the ages of the galactic clusters – and hence the age of LH 114 – are less than 10^7 yr. For the LH 114 cluster, Dopita et al. (1981) give the age $6\;10^6$ yr. This conclusion is reached from the bolometric magnitude and the turn-off magnitude from the main sequence of the blue supergiant of the cluster.

The stars 22–26, (28), 31, 32 are supergiants of type Ia–II when compared with the position of supergiants in the CD as determined by Walraven (1966) and van Genderen (1973), and shown in Fig. 2. When shifted along the reddening line in the $(V-B)/(B-L)$ and $(V-B)/(B-U)$ diagrams the stars 22, 23 approach the main sequence, in the $(V-B)/(U-W)$ diagram these stars are close to the supergiant branch. The stars 22, 23 are located in the bright nebular filament, hence the observed colours (as given in Table 1) are probably contaminated by local nebular emission. In order to illustrate the influence of nebular emission on the colour of a supergiant, we have added to the colours of the presumably correctly classified supergiant 24 (BII), with negligible reddening $A_{V_J}=0.08^{\rm m}$, the nebular emission of position E (Fig. 1b). The combined colours, shown by the dashed arrows in Fig. 2, agree approximately with the colours observed for stars 22, 23. We are thus inclined to classify the stars 22, 23 as supergiants (Table 2).

The stars 18, 20, and 21 are located in the direction of the northern shell in an area of low nebular emission as evident from the H_α map by Dopita et al. (1981). In this area the observed H_α emission is $\lesssim 20\%$ of the H_α emission observed at position E, hence from the observed stellar colours (Table 1) we subtract ~20% of the nebular emission E (Table 3). The correction in

Table 1. Stars of N 70 (LMC)

Star no.			V	$V-B$	$B-U$	$U-W$	$B-L$	V_J			$(B-V)_J$		
1	2	3						1	2	3	1	2	3
1*	1	2C	−2.301	−0.064	−0.076	−0.032	−0.035	12.64	12.7	12.50	−0.21	−0.3	−0.15
2*	2	1	−2.700	−0.068	−0.094	−0.038	−0.046	13.64	13.6	13.60	−0.22	−0.3	−0.19
3*	8	3	−3.235	−0.058	+0.020	−0.015	−0.004	14.97	14.6	14.94	−0.19	−0.1	−0.34
4*	3	7	−2.774	+0.033	−0.094	+0.020	−0.025	13.80	13.8	13.66	+0.07	0.0	0.08
5*	14	50	−3.210	+0.082	+0.017	+0.013	+0.022	14.89	(14.9)	15.46	+0.20	(0.3)	
6*	21	6	−3.421	−0.015	−0.003	−0.020	−0.023	15.43	(15.0)	15.51	−0.06	(0.4)	−0.39
7*	4	4	−2.803	−0.045	−0.026	−0.008	0.000	13.89	14.0	13.93	−0.14	−0.3	−0.19
8*	5	8	−3.060	−0.078	−0.052	−0.031	−0.055	14.54	14.3	14.46	−0.26	0.0	−0.25
9	16	9	−3.395	−0.042	−0.107	−0.058	−0.083	15.37	(14.9)	15.47	−0.13	(0.1)	−0.46
10*	6	11	−3.005	−0.062	−0.075	−0.031	−0.032	14.40	14.3	14.22	−0.20	−0.3	−0.25
11*	10	10	−3.206	−0.041	−0.018	+0.010	−0.012	14.90	14.7	14.86	−0.13	0.0	−0.24
12*	19	12	−3.390	−0.035	+0.025	−0.058	+0.032	15.36	(15.0)	15.43	−0.12	(0.1)	−0.37
13	12		−3.383	−0.050	+0.021	+0.011	+0.016	15.34	(14.8)		−0.16	(0.2)	
14	13		−3.350	+0.007	−0.036	+0.005	−0.031	15.25	(14.9)		−0.02	(0.3)	
15			−2.591	+0.268	+0.322	+0.238	+0.248	13.31			+0.65		
16	11		−3.175	−0.018	−0.009	−0.007	−0.003	14.81	14.7		−0.07	−0.2	
17	17		−3.340	−0.002	−0.011	+0.014	−0.025	15.22	(14.9)			(0.2)	
18		13	−2.395	+0.855	+0.672		+0.532	12.72		12.48	+1.88		+1.78
19	18	19	−3.375	+0.014	−0.032	+0.067	−0.032	15.31	(14.9)	15.46	+0.02	(0.3)	−0.21
20		14	−3.029	+0.721	+0.553	+0.435	−0.452	14.33		14.29	+1.61		+1.56
21		17	−2.999	+0.348	+0.277	+0.275	+0.218	14.32		14.27	+0.83		+0.68
(1983)			−2.989	+0.348	+0.284	+0.453	+0.201	14.33			+0.84)		
22			−3.268	+0.127	+0.110	+0.403	−0.014	15.02			+0.31		
23			−3.485	−0.001	−0.055	+0.182	−0.099	15.59			−0.02		
24	7		−3.132	+0.012	+0.308	+0.213	+0.056	14.70	14.5		+0.01	0.2	
25			−3.136	+0.238	+0.169	+0.302	+0.080	14.68			+0.58		
26	9		−3.190	+0.049	+0.292	+0.282	+0.029	14.84	14.7		+0.11	0.2	
27			−3.529	+0.036	−0.007	+0.036	−0.030	15.70			+0.09		
28			−3.111	+0.031	+0.128	+0.044	+0.026	14.65			+0.08		
29		16	−3.459	−0.022	−0.210	+0.094	−0.170	15.54		15.64	−0.07		−0.49
30		18	−3.571	−0.022	+0.036	+0.154	−0.065	15.82		15.84	−0.07		−0.26
31			−2.584	+0.098	+0.432	+0.228	+0.185	13.33			+0.25		
32			−2.738	+0.222	+0.445	+0.326	+0.178	13.71			+0.55		
33			−3.225	+0.315	+0.138	+0.198	+0.062	14.92			+0.77		
34			−3.261	+0.329	+0.400	+0.295	+0.237	15.01			+0.80		
35			−3.512	−0.029	−0.062	−0.035	−0.034	15.67			−0.09		
HD 270055			−1.687	+0.592	+0.767	+0.466	+0.576	11.00		10.9	+1.35		+1.18

Star no., V_J, $(B-V)_J$: 1 From this paper (see Fig. 1a), 2 from Rosado et al. (1981), 3 from Lucke (1972). Values in brackets are of reduced quality. The local nebular background is subtracted for the stars denoted by *. For star 21 we give the measurement for 1980 and 1983

Table 2. Stars of N 70 (LMC)

Star	$E(V-B)$	$E(B-V)_J$	AV_J	M_V			$(B-V)_{J_0}$	Classification	
				1	2	4		1+	4
CC 1	0.03	0.08	0.24	−6.2	−6.3	−6.5	−0.32	(OB V)	O8.5 Ib–IIF (P)
CC 2	0.03	0.08	0.24	−5.2	−5.4	−5.4	−0.32	OB V	O6 III–V ((F))
CC 3	0.02	0.05	0.16	−3.8	−4.4	−4.0	−0.26	B V	B0.2 III–VP
CC 4	(0.13)	(0.33)	(1.04)	(−5.8)	−5.2	−5.3	(−0.32)	(OB V)	B9 IE
CC 5	0.18	0.46	1.43	−5.1	−4.1		−0.32	OB V	
CC 6	0.08	0.21	0.64	−3.8	−4.0		−0.31	B V	
CC 7	0.04	0.10	0.32	−5.0	−5.0	−5.0	−0.28	B V	O7–9 V
CC 8	0.01	0.03	0.08	−4.1	−4.7	−4.5	−0.29	OB V	O9.5 V
CC 9	0.05	0.13	0.41	−3.6	−4.3	−3.4	−0.27	B V	B0 V
CC 10	0.04	0.10	0.32	−4.5	−4.7	−4.0	−0.34	OB V	(Binary?)

Table 2 (continued)

Star	$E(V-B)$	$E(B-V)_J$	AV_J	M_V			$(B-V)_{J_0}$	Classification	
				1	2	4		1+	4
CC 11	0.05	0.13	0.40	− 4.1	−4.3	−5.0	−0.30	B V	B0–3 III–V
CC 12	0.04	0.10	0.32	− 3.6	−4.0		−0.25	B V	
NC 13	0.02	0.05	0.16	− 3.4	−4.2		−0.23	B V	
NC 14	0.11	0.28	0.88	− 4.2	−4.1		−0.34	OB V	
NC 16	0.07	0.18	0.56	− 4.4	−4.3		−0.29	OB V	
NC 17	0.10	0.26	0.80	− 4.2	−4.1		−0.34	OB V	
S 18	(0.82)	(2.11)	(6.5)	(−12.4)			(+0.07)	B/A Ia (?)	
	(0.60)	(1.38)	(4.3)	(−10.2)			(+0.62)	F/G Ia+BC (?)	
S 19	0.07	0.18	0.56	− 3.8	−4.1		−0.18	B V (B II?)	
S 20	(0.70)	(1.80)	(5.6)	(− 9.8)			(+0.04)	B/A Ia (?)	
	(0.40)	(0.92)	(2.85)	(− 7.1)			(+0.77)	F/G Ia+BC (?)	
S 22	0.10	0.26	0.80	− 4.4			+0.05	B Ib–II	
S 23	0.02	0.05	0.16	− 3.2			−0.08	B II	
S 24	0.01	0.03	0.08	− 4.0	−4.5		−0.02	B II	
S 25	0.21	0.54	1.67	− 5.6			+0.06	B I	
S 26	0.05	0.13	0.40	− 4.2	−4.3		−0.02	B II	
S 27	0.12	0.31	0.97	− 3.9			−0.25	B V	
S 28	0.09	0.23	0.72	− 4.7			−0.18	B V	
S 29*	0.05	0.13	0.40	− 3.5			(−0.20)	OB V	
S 30*	0.05	0.13	0.40	− 3.2			(−0.20)	OB V	
S 31	0.05	0.13	0.40	− 5.7			+0.12	A I	
S 32	0.20	0.51	1.58	− 6.6			+0.04	BA I	
S 33*	0.35	0.90	2.79	− 6.6			−0.13	OB V	
S 35	0.08	0.21	0.65	− 3.6			−0.30	OB V	

Star no., M_V, classification: 1 From this paper (see Fig. 1a), 2 from Rosado et al. (1981), 4 from Dopita et al. (1981). CC: Stars of central cluster, NC: near central cluster, S: shell region. +: Tentative classification, * probably contamination with nebular emission. BC: Blue companion

Table 3. Nebulosities of N 70 (LMC)

Pos.	V	$V-B$	$B-U$	$U-W$	$B-L$	V_J
1	−4.822	−0.300	−0.359	+0.056	−0.307	19.0
3	−4.186	+0.231	−0.454	+0.377	−0.338	17.3
4	−3.951	+0.110	−0.311	+0.183	−0.228	16.7
5	−4.188	+0.136	−0.430		−0.346	17.3
7	−4.584	−0.069	−0.581	+0.379	−0.483	18.3
8	−4.005	+0.498	−0.295		−0.254	16.8
9	−4.018	+0.256	+0.178	+0.182	−0.084	16.9
10	−4.114	+0.152	−0.560	+0.483	−0.438	17.1
11	−4.481	+0.371	−0.737		−0.641	18.0
12	−4.497	+0.101	−0.601	+0.517	−0.508	18.1
B	−4.429	+0.040	−0.730	+0.752	−0.572	17.9
C	−4.265	+0.080	−0.633	+0.679	−0.515	17.5
D	−4.030	+0.123	−0.608	+0.623	−0.520	16.9
	(+0.088	+0.108	+0.052	+0.072	+0.035)	
E	−3.967	+0.126	−0.592	+0.581	−0.496	16.8
	(+0.093	+0.070	+0.042	+0.072	+0.041)	
F	−4.473	+0.300	−0.483	+0.275	−0.471	18.0
G	−4.462	+0.040	−0.458	+0.507	−0.342	18.0
H	−4.527	+0.095	−0.597	+0.437	−0.450	18.2
I	−4.342	+0.143	−0.685	+0.486	−0.576	17.7
J	−4.252	+0.132	−0.686	+0.539	−0.588	17.5
K	−4.352	+0.197	−0.380	+0.352	−0.316	17.7

The positions (pos.) of the measurements are shown in Fig. 1b. The values in brackets give the standard deviations determined from 3 measurements

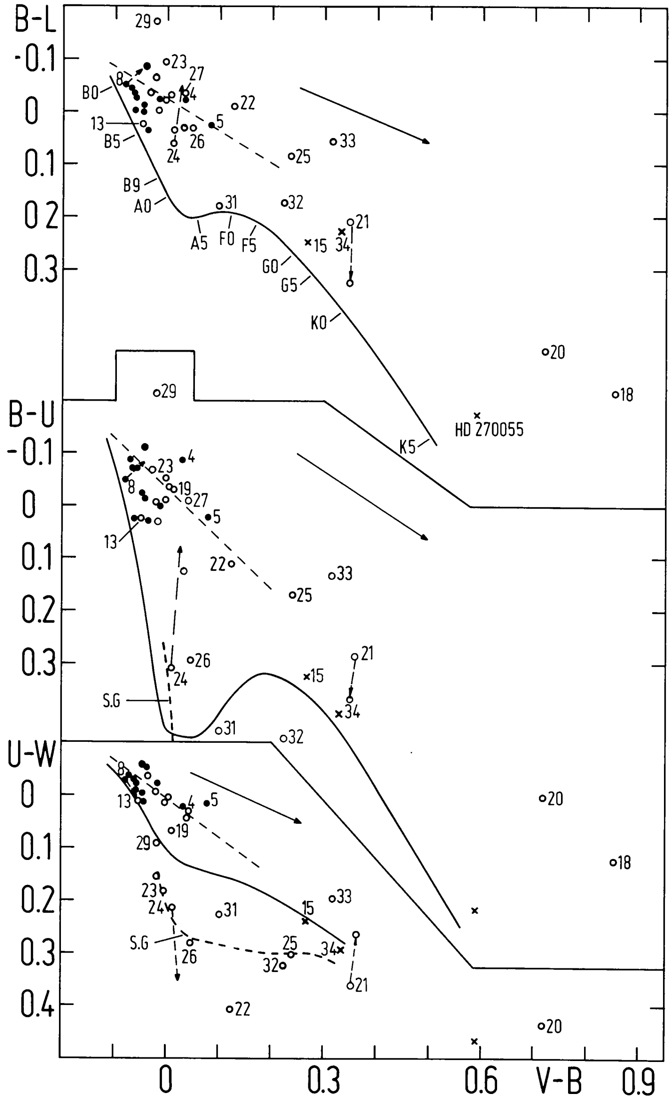

Fig. 2. Colour diagrams of the observed stars in N 70 (the numbers are from Fig. 1a and Table 1 (scales are in log intensity)). Cluster stars (corrected for local nebular background): filled circles, other stars in N 70: open circles, galactic field stars: crosses. Solid line: main sequence, dashed line: either black body colours or supergiant branch. The dashed arrows connected to the symbols show the effect if nebular emission is added (stars 8 and 24) or subtracted (star 21) (Sects. 2 and 3.1). The reddening directions are shown by the solid arrows

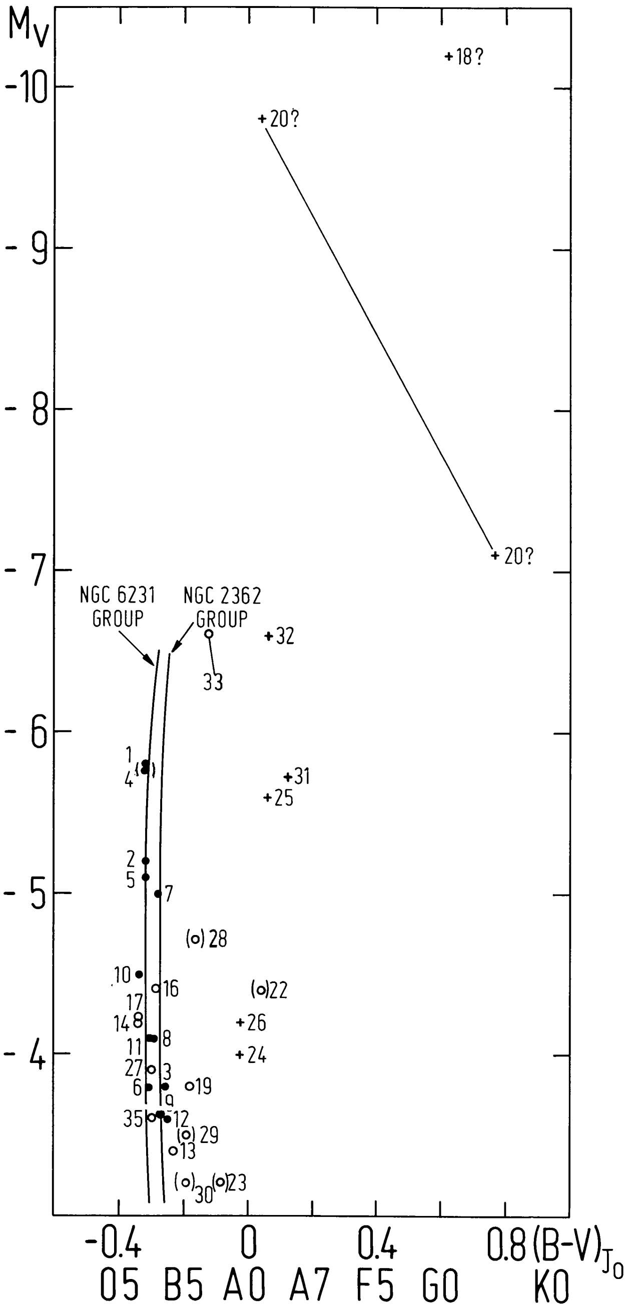

Fig. 3. HR diagram of the cluster stars: filled circles, possible suppergiants: crosses, and stars probably associated with the cluster: open circles; notation from Fig. 1a and Table 1. The isochronous curves based on normal points for two very young galactic cluster groups (NGC) are taken from Mermilliod (1981b)

stellar colours then is $\delta(V-B)\sim 0.005$ (i.e. the stars move in nearly vertical directions in the CD, Fig. 2), $\delta(B-L)\sim\delta(B-U)$ $\sim 0.1-0.15$, $\delta(U-W)\sim -(0.1-0.15)$. Applying these corrections, star 21 moves close to the main sequence (Fig. 2) indicating a possible foreground G0V star.

Application of the same corrections $\delta(V-B), \ldots, \delta(U-W)$ does not significantly change the extreme positions of stars 18 and 20 in the CD. In case these stars are normal stars without significant spectral anomalies, when shifted along the reddening line onto the main sequence, or onto the supergiant branch, early B type spectra are suggested. However, when assuming these stars to be high luminosity OB type stars with large reddening, the $(U-W)$ indices are abnormally red with respect to $(B-L)$ and $(B-U)$. The W intensity for star 18 was even so low that no reliable $(U-W)$ index can be given. The observed colours also do not agree with stars having dominant emission lines or emission shells. Red companions can explain the large $(V-B)$ indices, but cannot explain the relatively blue $(B-L)$ and $(B-U)$ indices, which indicate an intrinsic hot spectrum; a dominant red companion should also redden the $(B-L)$, $(B-U)$ and $(U-W)$ indices. Hence, red companions do not offer a satisfactory explanation for the high reddening and after correcting for this, for the large luminosity of these stars. Thus we conclude that the observed colours suggest reddened FG type supergiants with – physical or optical – blue companions (BC). Such a classification is

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substantiated by the fact that ~25% of galactic FGIa stars and Cepheids have physical blue companions (van Genderen, 1977, 1980; Pel, 1978; Parsons, 1981; Burki and Mayor, 1983). In Table 2 we give for stars 18 and 20 the tentative classifications as *B*/*A* type supergiants or FG type supergiants with a blue companion. We are inclined to adopt the latter identifications because the first ones give abnormally high luminosities. Anyway, whatever classification is taken, the extinction is of the order of $A_{V_J} \sim 3^m$. The colours of star 33 (Fig. 2) show some contamination by nebular emission. Applying the correction $\delta(V-B) \sim 0.005$ etc. (see above), the star moves to a more acceptable position. Also for this star we derive an extinction $A_{V_J} \sim 3^m$.

The supergiants are found exclusively in the direction of the shell region of the nebula, although the north-eastern shell is less well defined. Following the galactic number density of main sequence and supergiant stars (cf. Allen, 1977), the excess number of supergiants observed in the direction of N 70 suggests that these stars are associated with N 70. If we adopt this association, the HR diagram (Fig. 3) indicates that the supergiants 24, 25, 26, and 31 are somewhat older than the cluster stars. However, the presence in the nebular filaments of these more evolved stars is difficult to explain: when these stars were formed the shell was smaller, if existing at all.

3.2. *The extinction* A_{V_J}

When we assume the association of the stars 18, 20, and 33 with N 70, can we explain the extinctions $A_{V_J} = 4.3$ (6.5), 2.8 (5.6), and 2.8^m from the dust to gas ratio of the LMC? The extinction values are given in Table 2. The higher extinction values in brackets are obtained in case we adopt the less probable identification of the associated stars as types B/AIa (see Sect. 3.1). We remark that a large extinction in N 70 need not to be an exceptional case since from stellar *VBLUW* observations of N 43, N 159*A*, N 159, and N 160 we found for certain stars also extinctions of the order $A_{V_J} \sim 2\text{–}3^m$ (Greve et al., in preparation).

Let us assume that the extinction of the stars 18, 20, and 33 is produced in the LMC, by interstellar dust uniformly distributed and mixed with atomic hydrogen. Since the average interstellar gas-to-dust ratio in the LMC is four times higher than in the Galaxy (van Genderen, 1970; Koornneef, 1982) we apply

$$A_{V_J}/N(\text{H I}) \sim 1.5\ 10^{-22}\ \text{mag atoms}^{-1}\ \text{cm}^{-2} \qquad (2)$$

with $N(\text{H I})$ the column density of H I in the direction of N 70. From radio measurements of N 70, McGee and Milton (1966) and Dopita et al. (1981) derive $N(\text{H I}) \sim 1\ 10^{21}\ \text{cm}^{-2}$; from Lyman α interstellar absorption lines in the direction of two cluster stars of N 70 Page and Carruthers (1981) derive $N(\text{H I}) = (0.3\text{–}2)\ 10^{21}\ \text{cm}^{-2}$ (they classify the stars as O4–BII, however, they do not identify the stars). Using $N(\text{H I}) = (0.3\text{–}2)\ 10^{21}$ in Eq. (2), we obtain $A_{V_J} = (0.05\text{–}0.3)^m$. For a number of stars the extinctions derived from the photometry agree with this value.

However, for $A_{V_J} \sim 3^m$ as derived for the stars 18, 20, and 33 we obtain from relation (2): $N(\text{H I}) \sim 20\ 10^{21}\ \text{cm}^{-2}$. Although relation (2) refers to the average interstellar condition in the LMC, the value $N(\text{H I}) \sim 20\ 10^{21}$ seems to be unacceptably high, in particular when we consider that for 30 Dor, which has the largest reddening in the LMC (Caplan and Deharveng, 1984), de Boer et al. (1980) derived from Lyman α observations of associated stars $N(\text{H I}) \sim 6\ 10^{21}\ \text{cm}^{-2}$. We may speculate that the regions of N 70 in which the stars 18, 20, and 33 are located, are dense cloudlets (as found in SNR of the LMC, cf. Greve et al., 1982) which excape detection in radio observations with large beamwidths [14′ for McGee and Milton (1966) and Dopita et al. (1981)]. This assumption may be contradicted by the low H_α brightness measured for the same regions by Dopita et al. (1981) if we assume the low brightness being caused by low densities.

On the other hand, the extinction $A_{V_J} \sim 3^m$ may be due to circumstellar dust clouds (cf. Code, 1973). Since the spectral classification of the stars 18 and 20 is somewhat ambiguous anyway, this question can be decided only by additional observations.

3.3. *Intensity of nebular emission*

Using the calibration of the *VBLUW* system by Lub et al. (1979) and 55 kpc for the distance of the LMC, the absolute surface intensities in the *V*, *B* passbands are $J(V) \sim J(B) = 1.2\ 10^{-4}\ \text{erg cm}^{-2}\,\text{s}^{-1}\,\text{sterad}^{-1}$ for position *E* of the shell (see Fig. 1b). Using a continuum of $T_e = 8500$ K and the line strengths given by Dopita et al. (1981), the calculations give $J(V) = 3.3\ J(\text{H}\beta)$, $J(B) = 2.3\ J(\text{H}\beta)$, hence $J(\text{H}\beta) = (4\text{–}6)\ 10^{-5}\ \text{erg cm}^{-2}\,\text{s}^{-1}\,\text{sterad}^{-1}$. Since $J(\text{H}_\alpha)/J(\text{H}\beta) \sim 3$, this value of $J(\text{H}\beta)$ agrees with the value $J(\text{H}_\alpha)$ given by Dopita et al. (1981) for position *E*, i.e. $J(\text{H}_\alpha) \sim 1.1\ 10^{-4}$.

4. Conclusions

The collection of previous observations – optical and radio – of N 70 are discussed by Dopita et al. (1981) under the aspects of various models. The authors prefer the model, developed by Dopita (1981), of an emission nebula produced by stellar winds interacting with a collapsing H I cloud since only for this model a consistent interpretation of the morphology of the nebula and its optical and radio features can be given. We summarize our observations and deductions, which should be taken into account when discussing the astrophysics of N 70:

a) the central cluster LH 114 of N 70 is an association of roughly a dozen OBV stars and a few evolved stars of age less than 10^7 yr; Dopita et al. (1981) give the age of $6\ 10^6$ yr for the shell nebula.

b) there are a number of supergiants located in the direction of the shell region of the nebula. On the basis of the number density of stellar luminosity classes they may be associated with N 70. However, since a number of the supergiants are older than the cluster stars, their location in the direction of the shell is difficult to explain. Therefore one may debate the association of these stars with N 70.

c) there are three stars in the shell region of N 70 which indicate extinctions amounting to $A_{V_J} \sim 3^m$. This amount of extinction cannot be explained by the standard interstellar dust- and/or gas-to-dust ratio of the LMC. We are unable to decide whether this extinction is caused by a local concentration of dust or by circumstellar dust shells. Since for a few other nebulae of the LMC we have also found extinctions of the order of $A_{V_J} \sim 2\text{–}3^m$, it seems worthwhile to continue this investigation in order to establish eventually the source of extinction. For this spectroscopic and infrared observations are necessary.

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References

Allen, C.W.: 1973, Astrophysical Quantities, 3rd ed., The Athlone Press, Univ. of London

Blades, J.C., Elliott, K.H., Meaburn, J.: 1980, *Monthly Notices Roy. Astron. Soc.* **192**, 101

Brunet, J.P.: 1975, *Astron. Astrophys.* **43**, 345

Burki, G., Mayor, M.: 1983, *Astron. Astrophys.* **124**, 256

Caplan, J., Deharveng, L.: 1984, in *Structure and Evolution of the Magellanic Clouds*, IAU *Symp.* **108**, eds. S. van den Bergh, K.S. de Boer, p. 389

Code, A.D.: 1973, in *Interstellar Dust and Related Topics*, IAU *Symp.* **52**, eds. J.M. Greenberg, H.C. van de Hulst, p. 505

Danziger, I.J., Dennefeld, M.: 1976, *Publ. Astron. Soc. Pacific* **88**, 44

de Boer, K.S., Koornneef, J., Savage, B.D.: 1980, *Astrophys. J.* **236**, 769

Dopita, M.A.: 1981, *Astrophys. J.* **246**, 65

Dopita, M.A., Ford, V.L., McGregor, P.J., Mathewson, D.S., Wilson, I.R.: 1981, *Astrophys. J.* **250**, 103

Greve, A., van Genderen, A.M.: 1982a, *Astron. Astrophys.* **115**, 79

Greve, A., van Genderen, A.M.: 1982b, *Astron. Astrophys.* **111**, 185

Greve, A., van Genderen, A.M., Dennefeld, M., Danziger, I.J.: 1982, *Astron. Astrophys.* **111**, 171

Henize, K.G.: 1956, *Astrophys. J. Suppl.* **2**, 315

Isserstedt, J.: 1971, *Astron. Astrophys.* **41**, 175

Koornneef, J.: 1982, *Astron. Astrophys.* **107**, 247

Lasker, B.M.: 1976, *Royal Greenwich Obs. Bull.* **182**, 185

Lasker, B.M.: 1977, *Astrophys. J.* **212**, 390

Lasker, B.M.: 1981, *Publ. Astron. Soc. Pacific* **93**, 422

Lub, J.: 1980, Internal report

Lub, J., Pel, J.W.: 1977, *Astron. Astrophys.* **54**, 137

Lub, J., van Paradijs, J., Pel, J.W., Wesselius, P.R.: 1979, *Astron. Astrophys.* **72**, 82

Lucke, P.B.: 1972, Thesis, Univ. of Washington

Lucke, P.B., Hodge, P.W.: 1970, *Astron. J.* **75**, 171

McGee, R.X., Milton, J.A.: 1966, *Australian J. Phys.* **1**, 345

Meaburn, J.: 1978, *Astrophys. Space Sci.* **59**, 193

Mermilliod, J.D.: 1981a, *Astron. Astrophys.* **97**, 235

Mermilliod, J.C.: 1981b, *Astron. Astrophys. Suppl.* **44**, 467

Page, Th., Carruthers, G.R.: 1981, *Astrophys. J.* **248**, 906

Parsons, S.B.: 1981, *Astrophys. J.* **247**, 560

Pel, J.W.: 1976, *Astron. Astrophys. Suppl.* **24**, 413

Pel, J.W.: 1978, *Astron. Astrophys.* **62**, 75

Pel, J.W.: 1981, Internal report

Rijf, R., Tinbergen, J., Walraven, Th.: 1969, *Bull. Astron. Inst. Neth.* **20**, 279

Rosado, M., Georgelin, J.P., Y.M., Laval, A., Monnet, G.: 1981, *Astron. Astrophys.* **97**, 342

van Genderen, A.M.: 1970, *Astron. Astrophys.* **7**, 49

van Genderen, A.M.: 1973, *Astron. Astrophys.* **22**, 467

van Genderen, A.M.: 1977, *Astron. Astrophys.* **54**, 737

van Genderen, A.M.: 1980, *Astron. Astrophys.* **88**, 77

Walraven, Th.: 1966, IAU *Symp.* **24**, p. 274

Walraven, Th., Walraven, J.H.: 1960, *Bull. Astron. Inst. Neth.* **15**, 67

Walraven, Th., Walraven, J.H.: 1971, The Magellanic Clouds, ed. A.B. Muller, Reidel, Dordrecht, p. 117