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Preliminary study of the old open cluster NGC 6192

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Abstract. NGC 6192 is an old open cluster (of 6′.8 radius) with turn-off at about $M_V = 2.2$, corresponding to an age of 9×10^8 yr. It has a mean colour excess of 0.26 ± 0.08 (s.d., 11 stars) and a distance of 890 ± 130 pc. It appears to have an excess of giants compared to the Hyades, and also a main sequence to at least $V = 18$ or $M_V = 7$. The cluster appears superimposed, but not centreed, on a concentration of *B* stars with mean colour excess, $E_{B-V} = 1.14 \pm 0.24$ (29 stars) and distance 4.0 ± 0.5 kpc. Since these conclusions are based on photographic photometry calibrated with only 14 of 22 stars measured photoelectrically in the UBV, these results must be treated with caution, but certainly justify further photoelectric and spectroscopic work on the cluster.

Key words : Galactic cluster—photometry—evolution

1. Introduction

NGC 6192 (Mel 149, Cr 309; $\alpha_{2000} = 16^h40^m.3$, $\delta_{2000} = 43°22'$; $l = 340°.65$, $b = 2°.12$) is an old open cluster in the southern hemisphere close to the direction of the galactic centre. Ruprecht (1966) has classified it I2p, and Barkhatova (1950) has estimated a distance of the order of 430 pc. Its angular diameter is variously estimated between 7′ and 43′. No thorough study of this cluster has yet been made; consequently one of us, G.C.K., has obtained photoelectric and photographic data on the UBV system in order to make a preliminary study. In addition, M.P.F. has obtained direct and objective prism plates of the same area and we have incorporated these into this study.

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2. Observations

G.C.K. obtained photoelectric UBV data of 22 stars in the field of NGC 6192 in 1978 June using the 1.02m telescope of the Hale observatories at Las Campanas, Chile. The RCA C7237 photomultiplier, equipped with an S20 cathode, was cooled with dry ice. The UBV filters, chosen to match the Johnson system, were

$$U = \text{Corning } 9863 + 80\% \text{ solution } CuSO_4$$

$$B = \text{BG } 12 + \text{GG } 385 + 80\% \text{ solution } CuSO_4$$

$$V = \text{BG } 18 + \text{GG } 495$$

Standard stars of both blue- and red-colour index, from the lists of Johnson (1963) and Landolt (1973), were observed. The average internal standard deviations (s.d.) for a single observation of a non-variable star are ±0.03, ±0.02 and ±0.02 in V, $B - V$ and $U - B$ respectively. The results for these stars are shown in table 1. The photographic measurements are given in table 2.

Figure 1 shows a finding chart for the stars measured in NGC 6192. We obtained photographic photometry from plates taken with the 1.02m telescope by G.C.K., and the Michigan Schmidt telescope on Cerro Tololo by M.P.F. Plates in U, B and V were taken with each instrument. Unfortunately the 1.02m plates were affected by wind and the moon; and the position of NGC 6192 on the Schmidt plates was close

Table 1. Photoelectric observations in NGC 6192

Star #	V	s.d.	$(B-V)$	s.d.	$(U-B)$	s.d.	No. Obs.	Comment	Member	Residual (pe − pg) $\Delta(V)$	$\Delta(B-V)$	$\Delta(U-B)$
1	13.64	±0.13	1.21	±0.03	1.01	±0.24	2	Var?	n	−0.11	0.02	0.43
2	12.44	0.02	0.51	0 02	0.18	0.03	3	θ	m	0.09	−0.10	−0.41
5	13.62	0.02	0.55	0 05	0.31	0.04	3		m	0.07	−0.05	−0.05
7	14.85		0.79		0.25		1		m	0.06	−0.12	0.02
10	12.03	0.03	0.48	0.01	0.31	0.01	2		m	−0.02	−0.05	−0.02
11	12.26	±0.02	0.46	±0.01	0.11	±0.02	2		m	−0.10	0.09	−0.12
14	13.49	0.08	0.54	0.01	0.51	0.25	2	Var:	pm	−0.26	0.05	0.28
94	11.48		0.51		0.11		1		m	−0.03	−0.01	−0.04
95	12.00		0.60		0.28		1		m	0.05	0.10	−0.04
96	11.29	0.02	1.48	0.04	1.14	0.01	2	θ	m	0.13	0.31	−0.03
99	12.34	±0.04	0.50	±0.03	0.16	±0.01	3		m	−0.05	−0.05	0.12
102	12.86		0.55		0.12		1	U	m	−0.02	0.13	−0.30
105	12.52		0.56		0.21		1	θ	m	0.53	−0.18	−0.31
107	13.78		0.35		−0.04		1	Var?	B	1.32	−0.05	−0.29
109	10.91		0 75		0.82		1		pm	0.08	−0.05	0.00
111	12.64		0.40		−0.02		1		n	0.10	−0.06	−0.02
116	11.45		0.70		0.21		1		m	0.06	0.03	−0.03
131	12.52	0.03	0.64	0.01	0.23	0.04	3		m	−0.02	−0.04	0.05
137	11.27	0.19	1.59	0.13	1.26	0.14	3	θ	m	0.22	0.35	−0.60
181	10.89	0.04	0.45	0.02	0.20	0.04	3		m	−0.14	0.06	0.10
252	9.80	±0.01	0.22	±0.01	−0.01	±0.01	3		n	−0.03	−0.03	0.08
253	11.11	0.02	1.13	0.02	0.77	0.01	3	Var.	pm	−0.29	−0.54	−0.16

Note: The 8 stars with comments were not used to calibrate the photographic photometry. (Star 107 could have been mis-identified at the telescope, so its variability is doubtful.) A ninth star, 102, was not used to calibrate the U plates, but was used for B and V. The symbol θ indicates a star sufficiently overlapped with an adjacent image to make its use as a standard for photographic plates impossible.

Table 2. Photographic photometry

No.†	V	$B-V$	$U-B$	E_{B-V}	V_0	$(B-V)_0$*	Member		Sp.	Notes
1	13.75	1.19	0.58	*0.26*	*12.76*	*0.95*	n	3		1,2
3	12.35	0.61	0.59	*0.23*	*11.69*	*0.28*	m	1	F	2,6
3	14.84									
4	11.41	1.09	1.59	0.26	10.53	0.83	m?		G	3,5
5	13.55	0 60	0.36	*0.37*	*12.42*	*0.18*	m	1	A	6
6	14.51	1.02	−0.08	1.32	10.37	−0.30	B	1		7
7	14.79	0.91	0.13	*0.33*	*13.76*	*0.46*	m	1		
8	14.71	0.86	0.16	0.26	13 85	0.60	pm	2		
9	11.43	1.33	1.59	0.26	10.54	1.07	m?	3	gK0	3,5
10	12.05	0.53	0.33	*0.33*	*10.96*	*0.15*	m	1	A2	6
11	12.36	0.37	0.23	*0.15*	*11.77*	*0.31*	m	1	A5	
12	14.75	0.95	0.15	1.15	11.12	−0.20	pnB	1		
14	13.75	0.49	0.23	*0.36*	*12.32*	*0.18*	pm	3		2,8
15	14.39	0.78	0.31	0.44	12.95	0.34	m	2		
16	14.17	0.61	0.10	0.16	13.64	0.45	m	2		
17	12.99	0.64	0.21	0.30	12.01	0.34	m	1	A	6
18	11.83	0.85	0.37	0.26	10.97	0.59	pn	3	A7	6
19	11.44	0.55	0.22	0.29	10.50	0.26	m	1	A2	6
20	13.17	0.45	0.16	0.19	12.55	0.26	m	1		
21	14.78	0.94	0.09	1.17	11.09	−0.23	B	1		
22	12.89	0.57	0.36	0.40	11.60	0.17	m	1		
23	14.37	0.64	0.25	0.34	13.26	0.30	pm	1		
24	13.03	0.52	−0.11	0.80	10.52	−0.28	B	1		6
25	11.25	0.58	0.83	0.26	10.40	0.32	m?	2	A8	3,8
26	13.74	0.85	0.76	0.00	13.74	0.85	n	3		8
27	12.34	0.53	0.28	0.32	11.30	0.21	m	1		7
28	10.67	1.67	2.74	0.26	9.76	1.41	m?	3	gK4	3,5
29	14.17	1.10	0.38	0.26	13.29	0.84	n	3		
30	13.70	0.79	0.14	0.26	12.84	0.53	n	3		
31	14.24	0.81	0.12	0.99	11.11	−0.18	nB	3		
32	14.45	1.03	−0.35	1.35	10.22	−0.32	pB?	1		4,6
34	13.56	0.62	0.33	0.40	12.26	0.22	m	1		7
35	12.93	0.77	0.37	0.40	11.63	0.27	m	1		7
36	13.94	0.84	0.38	0.54	12.18	0.30	pm	2		7
37	14.30	1.41	−0.04	1.73	8.88	−0.32	pB?	3		4,7
38	14.20	0.80	−0.07	1.05	10.90	−0.25	B	1		
39	13.50	1.02	0.16	1.28	9.47	−0.26	B	1		
40	12.99	0.75	0.17	0.26	12.13	0.49	pn	3	F0	
41	13.36	0.80	1.29	0.26	12.50	0.54	n	3		3
42	13.14	0.56	0.39	0.50	11.53	0.06	pn	1		
43	14.86	0.95	0.02	1.22	11.03	−0.27	B	1		
44	14.71	1.09	−0.13	1.41	10.29	−0.32	pB	1		4
45	11.70	1.27	1.54	0.26	10.81	1.01	m	3		5
46	14.34	1.43	−0.28	1.75	8.86	−0.32	pB?	3		4
47	14.72	0.72	0.25	0.37	13.51	0.35	m	1		
48	13.67	1.61	0.69	0.26	12.76	1.35	n	3		5
49	14.40	0.65	0.50	0.26	13.55	0.39	m	2		
50	13.04	0.69	0.08	0.26	12.18	0.43	pn	3		
51	14.78									
52	14.34	0.69	0.52	0.26	13.48	0.43	m	2		
53	14.42	1.27	−0.17	1.59	9.44	−0.32	pB?	3		
54	14.83									
55	14.81	0.81	−0.06	1.05	11.50	−0.24	B	1		
56	13.98	0.51	0.06	0.12	13.59	0.38	m	1		
58	13.90	0.83	0.05	1.03	10.65	−0.20	pnB	1		

Continued

Table 2—*Continued*

No.†	V	$B-V$	$U-B$	E_{B-V}	V_0	$(B-V)_0$*	Member		Sp.	Notes
60	13.03	1.32	0.61				n	3		8
61	13.41	0.55	0.48	0.26	12.56	0.29	m?	2		3
62	12.07	0.81	0.82	0.26	11.21	0.55	n	3		3,8
63	13.50	1.32	0.37	1.56	8.59	−0.24	pB	1		8
64	12.70	0.67	0.53	0.26	11.85	0.41	pn	3		3,8
65	11.37	0.53	0.25	0.30	10.40	0.23	m	1		8
66	13.60	0.75	−0.28	0.84	10.96	−0.29	B	1		
67	14.83	0.61	0.36	0.41	13.50	0.20	n	1		
68	13.35	0.56	0.27	0.33	12.28	0.23	m	1		
69	14.83	0.80	0.02	1.01	11.64	−0.21	B	1		
70	12.86	0.69	0.53	0.26	12.00	0.43	pn	3		3
71	14.16	0.74	0.16	0.26	13.30	0.48	m	2		
72	14.19	0.88	0.32	0.26	13.32	0.62	pm	2		
73	11.86	1.29	0.71	0.56	9.98	0.73	pm	2		
74	12.10	1.43	0.19	1.75	6.62	−0.32	pnB	1		4,8
75	14.85									
76	14.06	0.82	0.10	1.01	10.87	−0.19	B	1		
77	14.78	0.91	0.18	0.26	13.91	0.65	pm	2		
78	12.44	0.75	0.33	0.47	10.91	0.28	pm	2		8
79	11.01	1.26	0.42	1.46	6.40	−0.20	pnB	1		8
80	14,27	0.82	0.17	0.26	13.41	0.56	pm	2		
81	12.77	0.64	0.18	0.27	11.89	0.37	m	1		7
82	12.56	0.52	0.18	0.24	11.78	0.28	m	1		7
83	14.51	1.00	0.19	1.20	10.72	−0.20	B	1		
84	14.78	0.78	0.27	0.38	13.53	0.40	m	1		
85	14.37	0.84	0.22	0.26	13.51	0.58	pm	2		
86	14.61	1.02	0.32	0.26	13.74	0.76	pn	3		
87	13.91	0.90	0.23	0.26	13.04	0.64	pn	3		
89	11.87	1.63	0 89	0.26	10.86	1.37	m	3		5,8
90	12.20	0.67	0.61	0.26	11.35	0.31	m?	2		3,8
91	11.31	1.25	1.46	0.26	10.42	0.99	m?	3		3,7
92	11.60	0.40	0.22	0.21	10.92	0.19	m	1		
93	12.70	0.65	0.31	0.40	11.40	0.25	m	1		
94	11.51	0.50	0.15	*0.17*	*10.92*	*0.34*	m	1	A5	
95	11.95	0.50	0.32	*0.35*	*10.86*	*0.25*	m	1	F0	
96	11.16	1.17	1.17	*0.26*	*10.40*	*1.22*	m	3	gK	2, 8
97	14.88	0.85	0.11	0.26	14.02	0.59	pm	2		
98	14.38	1.29	0.16	1.60	9.36	−0.31	B	1		
99	12.39	0.55	0.04	*0.21*	*11.66*	*0.29*	m	1	A5	
100	14.83	0.89	0.13	0.26	13.96	0.63	pm	2		
101	13.80	0.75	0.15	0.26	12.94	0.49	pm	2		
102	12.88	0.42	0.42	*0.20*	*12.21*	*0.35*	m	1	F	
103	14.71	0.88	0.23	0.26	13.84	0.62	pm	2		
104	13.10	0.93	0.68	0.26	12.23	0.67	n	3		
105	11.99	0.74	0.52	*0.26*	*11.67*	*0.30*	m	3	F	2,8
106	14.17	0.63	−0.10	0.84	11.52	−0.21	B	1		
107	12.46	0.40	0.25	*0.46*	*12.32*	*−0.11*	pB	1		1,2
108	14.05	1.14	0.28	1.35	9.79	−0.21	pB	1		8
109	10.83	0.80	0.84	*0.26*	*10.05*	*0.49*	pm	3	F0	7
110	13.80	0.58	0.04	0.00	13.80	0.58	n	4		6
111	12.50	0.34	0.00	*0.00*	*12.50*	*0.34*	n	4		6
112	14.82	0.90	0.09	1.11	11.32	−0.21	B	1		
114	14.30	0.79	0.11	0.26	13.44	0.53	pm	2		
115	14.53	0.65	0.03	0.00	14.53	0.65	n	4		
116	11.39	0.67	0.24	*0.26*	*10.60*	*0.44*	m	2	gF	

Continued

Table 2—*Continued*

No.†	V	$B-V$	$U-B$	E_{B-V}	V_0	$(B-V)_0$*	Member		Sp.	Notes
117	13.31	0.80	0.26	0.26	12.45	0.54	pn	3		7
118	14.20	0.85	−0.06	1.11	10.71	−0.26	B	1		
119	13.42	1.02	0.21	1.22	9.57	−0.20	pB	1		
120	14.91	0.74	0.25	0.26	14.05	0.48	m	2		
121	14.78	0.88	0.15	0.26	13.91	0.62	pm	2		
122	14.76	0.79	−0.32	1.20	11.00	−0.32	pB	1		4
123	13.92	0.81	0.17	0.26	13.06	0.55	pn	3		
124	13.51	0.68	−0.08	0.90	10.67	−0.22	B	1		
125	13.40	0.92	0.89	0.00	13.40	0.92	n	4		8
226	12.89	1.21	0.81	0.26	12.01	0.95	n	3		8
127	13.68	1.36	−0.11	1.68	8.42	−0.32	pB?	3		4
129	14.64	0.69	0 08	0.26	13.78	0.43	m	2		
130	14.80	0.72	0.02	0.26	13.94	0.46	m	2		
131	12.54	0.68	0.18	*0.31*	*11.51*	*0.33*	m	1	F0	
133	14.90	0.70	0.18	0.26	14.04	0.44	m	2		
134	14.85									
135	14.34	0.55	0.56	0.26	13.49	0.29	n	3		3
136	12.57	0.68	0.75	0.26	11.72	0.42	n	3		3,8
137	11.05	1.24	1.96	*0.26*	*10.37*	*1.33*	m	3	gK	2,5,8
138	13.97	1.12	−0.05	1.44	9.46	−0.32	B	1		
139	14.44	0.80	0.27	0.26	13.58	0.54	m	2		
140	14.81	0.76	−0.13	1.02	11.60	−0.26	B	1		
141	14.37	1.03	0.24	0.26	13.50	0.77	n	3		
142	14.92									
143	14.62	1.01	−0.24	1.33	10.45	−0.32	pB?	3		4
144	14.08	1.05	0.04	1.33	9.90	−0.28	B	1		
145	13.15	0.70	0.63	0.26	12.29	0.44	pn	2		3
146	13.98	0.99	0.29	0.26	13.11	0.63	pn	3		
147	14.85	0.95	−0.01	1.22	11.02	−0.27	B	1		
148	12.22	1.35	1.92	0.26	11.33	1.09	pm?	3	K	3,5
149	14.70	0.79	0.05	0.26	13.84	0.43	m	2		
150	14.25	0.97	−0.06	1.26	10.29	−0.29	B	1		
151	13.98	1.10	−0.18	1.42	9.53	−0.32	pB?	3		4
152	14.53	0.90	0.31	0.26	13.66	0.64	pn	3		
153	14.20	1.52		0.26	13.30	1.26	n	3		
154	14.08	1.02	0.07	1.27	10.09	−0.25	B	1		
155	13.46	0.62	0.33	0.40	12.16	0.22	m	1		
156	14.40	0.92	0.42	0.59	12.47	0.33	pm	2		
157	13.28	0.55	−0.11	0.74	10.94	−0.19	B	1		
158	12.97	0.49	0.31	0.34	11.87	0.15	m	1		
159	14.38	0.55	0.02	0.00	14.38	0.55	n	4		
160	14.31	0.64	0.01	0.00	14.31	0.64	n	4		
161	14.80	0.86	0.40	0.26	13.94	0.60	m	2		
162	14.46	0.86	0.31	0.26	13.60	0.60	pm	2		
163	14.28	1.11	−0.15	1.43	9.80	−0.32	pB?	3		4
164	12.08	0.86	0.29	0.26	11.22	0.60	pm	2	F3	
165	14.26	1.01	0.13	1.24	10.35	−0.23	B	1		
166	14.30	1.37		0.26	13.41	1.11	n	3		
167	13.33	0.62	−0.01	0.00	13.33	0.62	n	4	F	
168	13.82	0.80	0.31	0.07	13.59	0.73	pn	4		
169	14.31	0.85	0.17	0.26	13.45	0.59	pm	2		
170	14.76									
171	14.29	0.85	0.11	1.04	11.00	−0.19	nB	3		
173	14.88									
177	14.84	0.90	−0.05	1.17	11.16	−0.27	B	1		

Continued

Table 2—*Continued*

No.†	V	$B-V$	$U-B$	E_{B-V}	V_0	$(B-V)_0$*	Member		Sp.	Notes
178	14.09	1.42	0.40	1.68	8.81	−0.26	pB	1		
179	14.87									
181	11.03	0.39	0.10	*0.22*	*10.18*	*0.23*	m	1	A3	
182	13.98	1.04	0.24	0.26	13.11	0.78	pn	1		8
187	13.36									
192	14.60	1.09	−0.24	1.41	10.18	−0.32	pB?	3		4
204	14.83									
209	14.91									
215	14.61									
219	14.91									
223	14.55	1.16	0.17	1.43	10.06	−0.27	B	1		8
224	14.56	1.09	0.06	1.37	10.26	−0.28	B	1		8
226	14.39									
229	13.94	1.15	0.31	0.26	13.06	0.89	n	3		8
233	14.92									
236	14.76									
238	14.54	1.04	0.21	0.26	13.67	0.78	n	3		
239	14.47									
243	14.82	0.93	0.18	0.26	13.95	0.67	pm	3		
244	14.68	1.02	−0.03	1.31	10.57	−0.29	B	1		
245	14.74	0.81	0.01	1.07	11.37	−0.26	B	1		
247	14.76									
251	14.80	0.90	−0.19	1.21	11.01	−0.31	pB	1		
252	9.83	0.25	−0.09	*0.33*	*8 78*	*−0.08*	n	1	dB9	
253	11.40	0.67	0.93	*0.26*	*10.23*	*0.87*	pm	3	gG4	1,2

Notes to table II

†Some stars too faint for photographic photometry are omitted.
*Italics indicate that the reduction is from the photoelectric data in table 1.

Membership

- m — probable member of NGC 6192
- pm — possible member of NGC 6192
- pn — probable nonmember of NGC 6192 and the background B star group
- n — nonmember of both NGC 6192 and the background B star group
- B — possible member of a background B star group
- pB — as for B, above, but less likely
- pnB — probably a B star, but not likely a member of the background group
- 1 — a unique reddening solution was present and used
- 2 — no unique reddening solution was present. E_{B-V} (often 0.26) was assigned to suit membership
- 3 — no reddening line solution was present for $B-F$ stars, or the star was a red-giant. The former had colour excess adopted, the latter assigned E_{B-V} = 0.26
- 4 — unreddened

Notes

1. Variable?
2. Photoelectric standard, not usable for photographic photometry
3. $(U-B)$ too red
4. $(U-B)$ too blue
5. not-plotted in two-colour diagram
6. slight overlap on photographic plates
7. overlapped by a brighter image
8. seriously overlapped

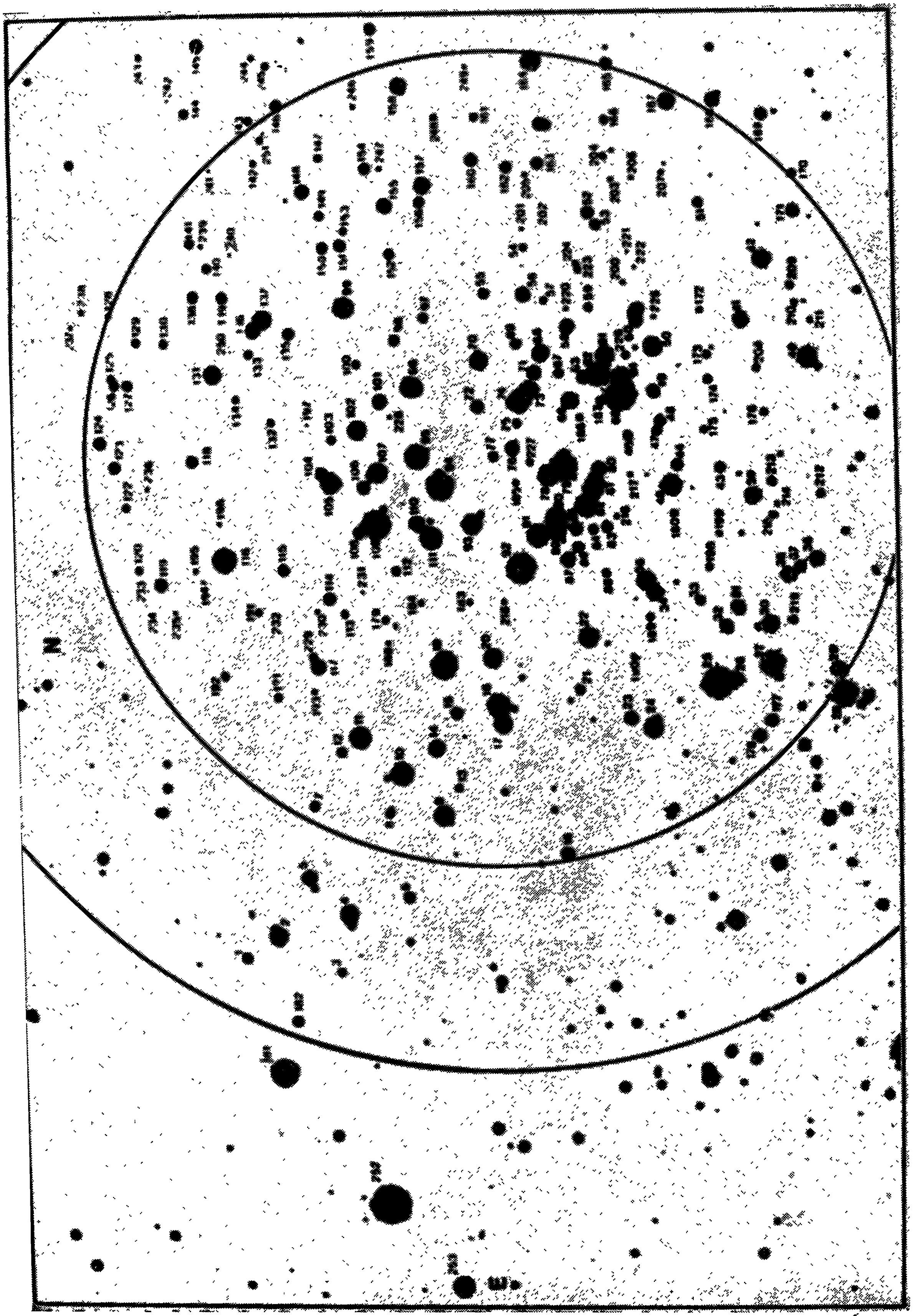

Figure 1. Finding chart for NGC 6192 and vicinity. The outer circle represents the boundary of the cluster and has radius 6′.8; three quarters of the members lie inside the inner circle of 4′.1 radius.

to the vignetting circle, with the consequence that not all plates could be used. Three plates in U, and four in each of B and V were measured by GCK using the Cuffey iris astrophotometer of St. Mary's University. On these a total of 180 stars in NGC 6192 and the surrounding field were bright enough for magnitude and colour estimates. Of the 22 stars measured photoelectrically, only 14 could be used as standards since 4 had overlapping photographic images (2, 96, 105 and 137) and 4 appeared to be variable (1, 14, 107, 253 and possibly 96 and 102). In addition stars 11 and 181 showed fairly large differences between the photographic and the photoelectric, but were included in the calibration. The difference between the two sets of results shows a standard deviation (s.d.) of $\pm$ 0.07 in each of V, $B - V$ and $U - B$. The *internal* standard errors of the mean (s.e.) from the photographic photometry are 0.03, 0.04 and 0.06 respectively, not significantly different from those frequently found for Schmidt photographic photometry. Table 2 gives the results of the photographic measures, for which no significant colour equation was found.

Included in table 2 are the photographic magnitudes and colours, the colour excess, V_0 and $(B - V)_0$ (corrected for extinction), membership and primary reason for the decision, spectral class and notes. Spectral classes are based on objective prism spectra classified by MPF on two 4° (280 A mm^{-1}) and two thin prism (1360 A mm^{-1}) plates taken in the blue with the Michigan Schmidt. Because of overcrowding the spectral classes of the 28 stars classified have an internal standard deviation of $\pm$2 subclasses; consequently these classifications merely serve to confirm the photometric solutions. Star 252 = HD 150081 is classified B9 V by Houk (1978). The difference between the photometrically assigned classes and those assigned spectroscopically is about 1 $\pm$ 3 subclasses.

3. Reduction and analysis of results

Cluster diameter

The radius of the cluster is about 6′.8 based on star counts in concentric circles centreed on star 77. Counts were made to the plate limit, and to V = 14.8 and 13.4; the latter limits are the approximate magnitudes of the faintest and second faintest photoelectric standards. The results are shown in figure 2; they indicate 244 $\pm$ 25 members of 526 $\pm$ 23 stars to the plate limit. The corresponding results for the other counts are 115 $\pm$ 15 of 193 $\pm$ 14, and 48 $\pm$ 9 of 72 $\pm$ 8 respectively. The errors are based on Poisson statistics. Thus the cluster would appear to have members to the plate limit of about $V = 18^{\mathrm{m}}$, $M_V = 7$ (dK5), accepting the derived distance modulus below.

Extinction

We estimate the cluster extinction to be $E_{B-V} = 0.26 \pm 0.08$ (s.d.) on the basis of the 11 stars measured photoelectrically which have a unique reddening line solution. As may be seen from the two-colour diagram, figure 3, there appears to be significant variable extinction present in the cluster. Since this is the case, all stars in table 2 have been individually corrected for interstellar extinction using the reddening lines and the ratio of total-to-selective absorption of Schmidt-Kaler (1965), namely

$$R = A_V/E_{B-V} = 3.2 + 0.21\,(B - V)_0.$$

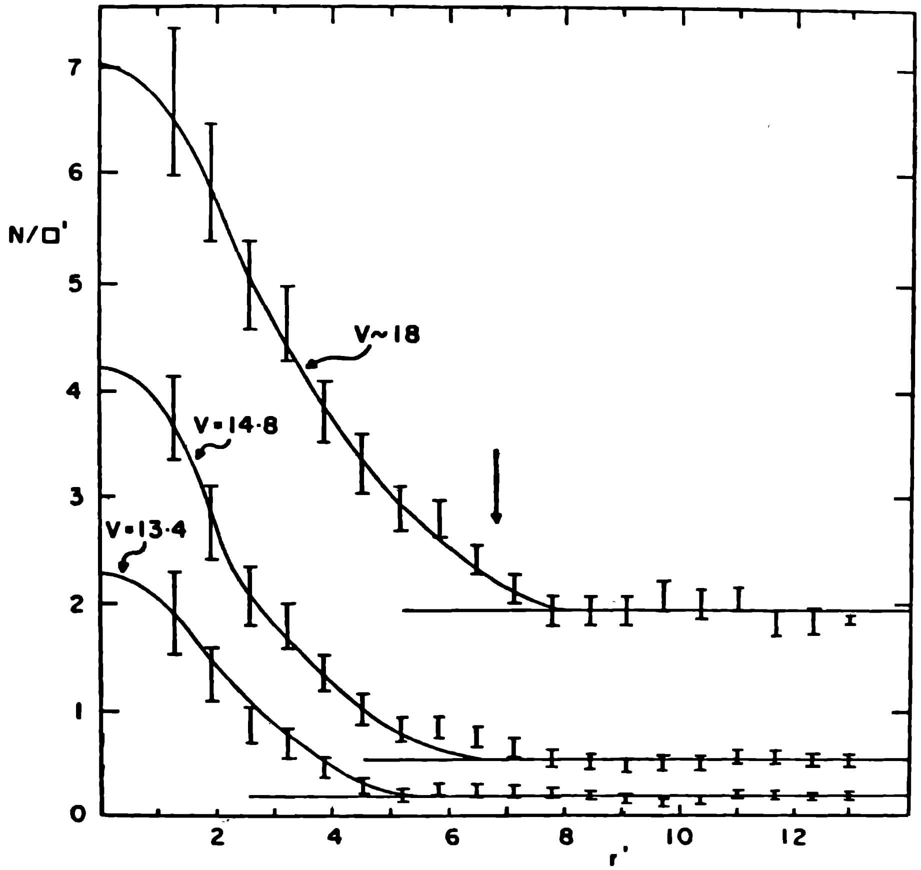

Figure 2. Star counts to three limiting magnitudes in NGC 6192. An angular radius of 6′.8 is adopted for the cluster as shown by the arrow. These counts support cluster membership to the plate limit of $V \simeq 18$. Star counts are based on three overlapping rings with ring 10 at 6′.8.

Where no unique extinction solution was apparent, one was chosen consistent with the star's membership in the cluster, if such was possible. The colour excess and reason for its choice are given for each star in table 2. Since both the scatter in the photographic colours, and that introduced by variable extinction, are about ± 0.08, the results for individual stars must be treated with considerable doubt, requiring confirmation by photoelectric photometry The mean colour excess for 21 stars classified as probable members, 'm', of NGC 6192 on the basis of photographic photometry alone, and with unique reddening line solutions, is 0.31 ± 0.09 (s.d.), significantly greater than found photoelectrically.

As is obvious from figure 3, many of the stars occupy *forbidden* parts of the diagram, or appear too blue in $(U - B)$ to be cluster members. Asssuming that the photographic photometry contains no systematic errors, *though this would have to be confirmed photoelectrically*, we find 46 B stars that might well lie at a common distance of 4.0 ± 0.5 kpc, with a mean colour excess, $E_{B-V} = 1.24 \pm 0.27$ (s.d.). If we exclude stars for which the photometry may be suspect (notes 3 to 8 in table 2), the group reduces to 29 stars with $E_{B-V} = 1.14 \pm 0.24$ (s.d.) at the same distance, againa small significant difference. We also note that half of these stars lie within $0^m.5$ of the calibration limit, and could therefore have $(U - B)$ colours significantly in error, particularly if star 7 were to have incorrect photoelectric photometry

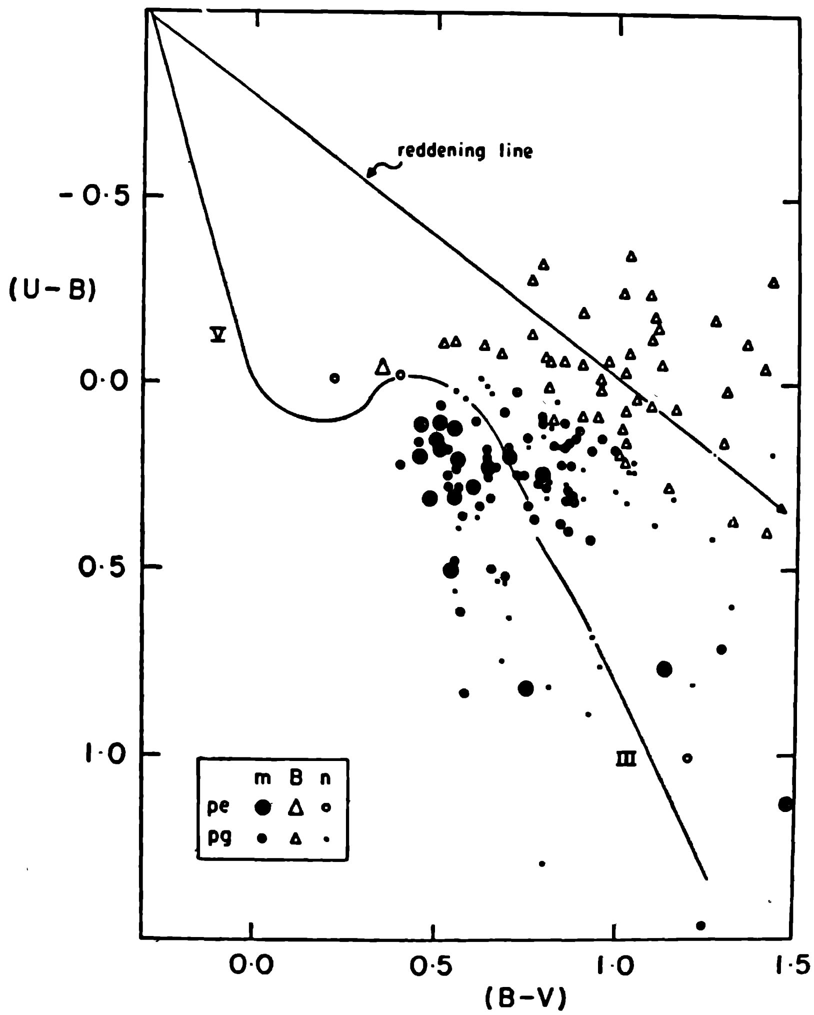

Figure 3. Two-colour diagram for NGC 6192. The intrinsic relationship for O−F dwarfs and G−K giants is shown, as well as a reddening line. Symbols are as given in the figure, 'm' indicating probable and possible members of the cluster, 'B' the same for members of the distant B star grouping, and 'n' possible and non-members of either.

(which we have no reason to suspect). A similar O and B star concentration has been suggested by Mitchell (1980) and Luiken Miller (1982) behind NGC 6383 (l = 355.7, b = 0.1), though the dangers of basing such conclusions on photographic photometry alone are well illustrated in the case of Haffner 18ab and 19 (l = 243.1, b = 0.5; FitzGerald & Moffat 1976).

Cluster membership and distance

Membership in NGC 6192 has been determined by examining the positions of the individual stars in the two-colour diagram (figure 3) and the colour-magnitude diagram both corrected (figure 4) and uncorrected for extinction (figure 5). Using the ZAMS of Schmidt-Kaler (1965) we find a distance modulus of $V_0 - M_V = 9.75 \pm 0.30$, allowing for a deviation of approximately $0^m.1$ in $(B - V)$ to the left of the ZAMS to account for errors in the photographic photometry. Membership criteria also allows for the possibility of duplicity. We note that this distance modulus

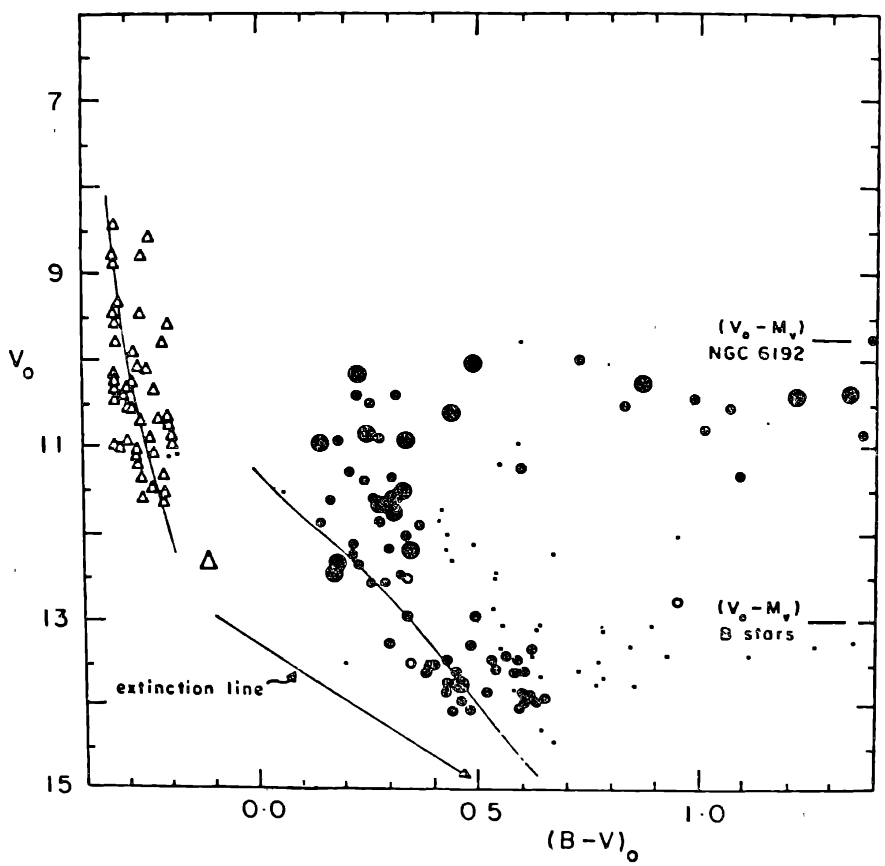

Figure 4. Colour-magnitude diagram corrected for extinction for all stars in the field of NGC 6192. Symbols are as in figure 3. Two zero-age main sequences are drawn, one at $V_0 - M_V = 9.75$, the other at 13.0. The lowest line in the diagram is an extinction line of slope 3.2.

depends heavily on the photoelectrically measured stars 5, 7 and 14, but little on the mean colour excess. In figure 4 the line below the ZAMS fit for NGC 6192 is an extinction line of the slope 3.2.

Of the 147 stars with colours measured within 4′.1 of the cluster centre 59 are considered members of the cluster and 29 to be background B stars. Within 6′.8 of the cluster centre the totals are 197, 76 and 47 respectively. Of the 4 stars measured outside this limit two are possible cluster members. Thus it appears that there are fewer cluster members than suggested by star counts; on the other hand the total number of members and background B stars is consistent with the counts. Thus it is possible, as with NGC 6383, that we are observing a nearby cluster superimposed on a more reddened background B association, as discussed below.

Based on a distance of 890 pc and an angular radius of 6′.8 we find a cluster radius of 1.76 pc. Of the 78 stars suggested as members of the cluster 76% lie within 4′.1, or 1.06 pc of the centre, indicating a compact cluster of moderately high concentration. It is also interesting to note that the star counts for stars with $V < 13.4$ favour a radius $\simeq$ 4′.1.

Possible distant B-star concentration

In addition to the 78 stars suggested as members of the cluster, 47 are suggested as background B stars with a common distance of 4.0 ± 0.5 kpc, on the basis of their

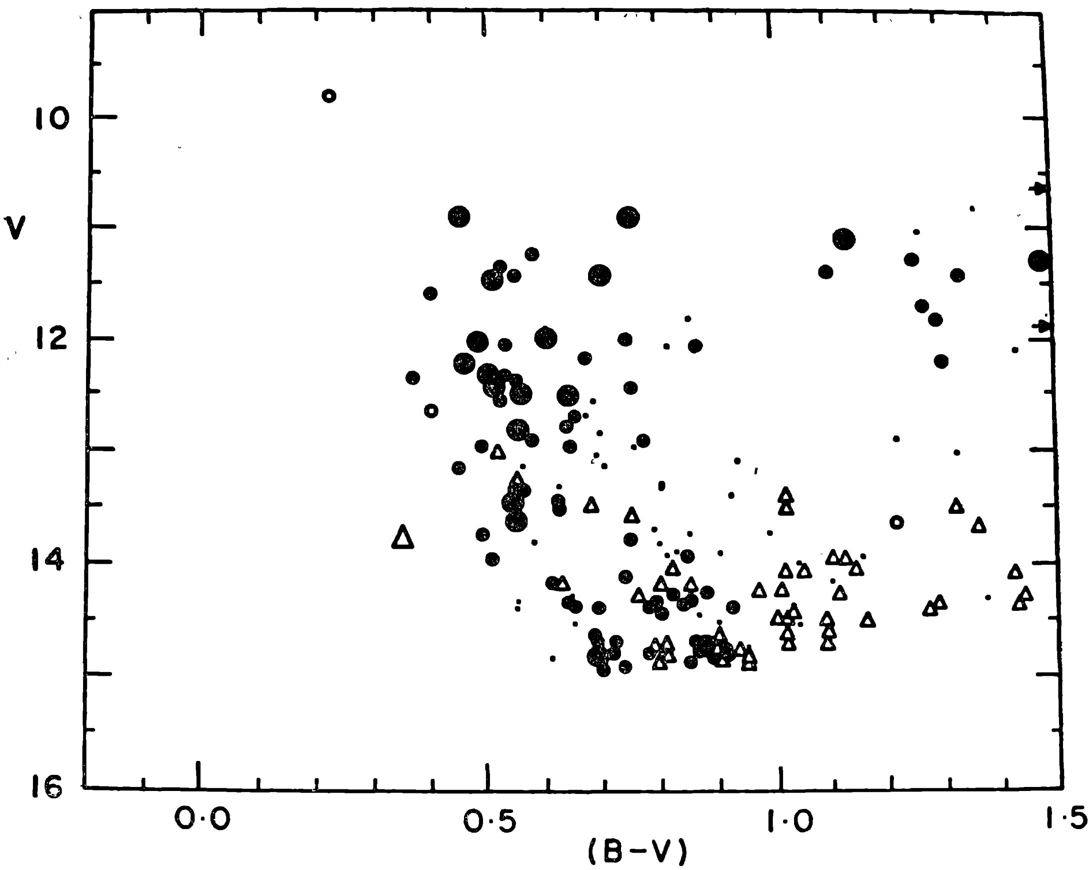

Figure 5. V versus $(B-V)$ for stars in and around NGC 6192. Symbols are as in figure 3.

photometric properties. This suggestion could well be caused by inaccurate photographic $(U-B)$ colours, as indicated above. However, if these stars are indeed B stars, they would appear to be associated with the − II arm, as may be seen by comparison with the map of spiral structure of Vogt & Moffat (1975). The distribution of possible B stars is toward the south-west of the cluster and not highly concentrated, tending to support its existence. In addition, the mean extinction of both NGC 6192 and the possible B group are consistent with the run of extinction found in this direction by FitzGerald (1967, 1968), though the general distribution of interstellar dust at this galactic longitude is extremely patchy. From a one-hour exposure in the blue using the Schmidt, NGC 6192 is seen to lie in one of the more dust free regions, thus supporting the idea that distant B stars might be seen through a local region of lower absorption. It is noted that even if B stars were distributed at uniform space density along the line of sight, the presence of heavy obscuration at any given distance would superficially indicate a B star concentration just short of that distance; such could be the case here.

4. Discussion

NGC 6192 appears to be a rather old open cluster, with bluest stars having $(B-V)_0 \simeq 0.2$, and turn-off at $M_V \simeq 2.2$, equivalent to an age of about 9×10^8 years (Allen 1973), in reasonable agreement with the age obtainable from Demarque & McClure (1977). A comparison with the Hyades indicates that NGC 6192 has about the same age. The cluster does differ from the Hyades, however, in that about 12 stars appear to be red-giant members, considerably more than in the latter cluster; we note that half these objects have their observed $(U - B)$ too red, and this might indicate nonmembership and/or poor photographic photometry. In addition, this giant sequence differs markedly from that calculated by Demarque & McClure (1977), perhaps indicating some physical difference between the cluster stars and the models, or the need to improve the cluster photometry and/or the theoretical models.

Examination of the colour-magnitude diagram, figure 4, reveals a distinct gap in the main sequence at $(B - V)_0 \approx 0.4$. It has a width in $(B - V)_0$ of $\approx 0^m.15$ and in V_0 of $\approx 0^m.8$. This gap has been detected in other clusters including χ Persei, the Pleiades, I Orionis (Bohm-Vitense & Canterna 1974), and NGC 1039 (Canterna *et al.* 1979). It is associated with the gap predicted by Bohm-Vitense (1958). The cluster probably has a luminosity function that increases with magnitude from 16.3 ± 2.3 (s.d.) per magnitude interval for $0 < M_V < 4$ to an average of approximately 27 for $4 < M_V < 7$ assuming the same fraction of stars are members as for $M_V < 4$.

In summary, it is evident that NGC 6192 is a fairly old cluster with little interstellar extinction, lying about 0.9 kpc from the sun in the direction $l = 341°$. As such it is an interesting object for further photoelectric and spectroscopic study. The present data suggest that the gap predicted in the main sequence is present at $(B - V)_0 \sim 0.4$, but that the giant branch could be overpopulated and does not lie in the position predicted by Demarque & McClure. Unfortunately the present data are not sufficiently accurate to allow a more thorough discussion of the cluster, but do provide the information needed to allow a thorough further study to be undertaken. Such a study would also confirm or reject the possible *B* star concentration at 4 kpc on which NGC 6192 appears to be partially superimposed. The results of higher quality study should give important added information on the stellar content of old open clusters, and possibly on the metal abundance of such objects as a function of age and position in the galaxy.

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