The galactic cluster IC 2602 (Errata: 17 310)
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THE GALACTIC CLUSTER IC 2602

BY L. L. E. BRAES

The paper deals with photoelectric and photographic photometry of stars in IC 2602, observed at the Cape Observatory, and with the determination of proper motions for a number of these stars, based on meridian and photographic data available at present. The distance of IC 2602 is found to be 155 pc and its age can be estimated to be about 8 $\times$ 10^6 years. Very probably it is a stable configuration. The W Ursae Majoris type variable BS Car does not belong to the cluster.

1. *Introduction*

IC 2602, consisting of a nearly circular group of bright stars centred on θ Carinae, is situated at R.A. $10^h41^m.2$, Decl. $-64°8'$ (1950) ($l^{II} = 289°.6$, $b^{II} = -4°.9$), south of the well known Carina emission region.

Previously published data about the cluster are given by ALTER, HOGG, RUPRECHT and VANYSEK (1958, 1959, 1960, 1961). Some of the data given in this paper had already been reported by the author (1961). Quite recently a photoelectric and spectroscopic investigation was made by WHITEOAK (1961).

On the occasion of a stay at the Royal Observatory, Cape of Good Hope, the author was given the opportunity to use the Victoria 24-inch refractor for three-colour photoelectric observations of stars in this group. In addition use was made of the photographic photometry contained in the *Cape Photographic Catalogue* for 1950.0 (called CPC in the following) and two supplementary photographic plates were taken with the double camera mounted on the Cape astrographic refractor. New proper motions were obtained by means of a combination of available meridian observations, the proper motions from the *General Catalogue* and those presented in the CPC.

2. *The photometric observations*

a. *The photoelectric measurements*

Observations in yellow, blue and ultraviolet, of stars down to about 11 visual magnitude, were made with the photoelectric equipment attached to the Cape 24-inch telescope. The stars measured photoelectrically and photographically are shown in Figure 1. The identification numbers in this figure are the running numbers in Table 1.

Four cluster stars (Nos. 29, 37, 49 and 53), previously observed photoelectrically at the Cape, were chosen as standards. The blue and yellow magnitudes, b and y, measured with the Victoria refractor were transformed to the JOHNSON and MORGAN (1953) system according to the relations:

$$V = y - 0.012\,(b-y) - 0.055,$$
$$B - V = 0.912\,(b - y) + 0.274 + \text{curvature correction.}$$

The refractor ultraviolet-blue colour indices $(U-B)_c$ are presented on the system of *Cape Mimeogram* No. 11 ("Standard Magnitudes in the *E* Regions", 1961).

Of the 42 stars observed photoelectrically, 37 have four observations made on different nights. From the mean range in the set of these 37 $\times$ 4 data the following probable errors were computed: $\pm^m.0035$ for V, $\pm^m.0029$ for $(B-V)$ and $\pm^m.0035$ for $(U-B)_c$. The number of observations for the remaining stars ranges from 2 to 7.

Photoelectric measurements of another 30 stars have been made by WHITEOAK (1961). In Table 1 these data are indicated by (W).

b. *The photographic data*

The CPC, Zone $-56°$ to $-64°$ (1958) and Zone $-64°$ to $-68°$ (unpublished), gives the blue and yellow magnitudes *SPg* and *SPv*, and the colour index $SCI = SPg - SPv$, on the system of *Cape Mimeogram* No. 3 ("Standard Magnitudes in the *E* Regions. The 1953 *S* System", 1953), for another 13 stars in the region of IC 2602. These quantities were transformed to the JOHNSON and MORGAN (B, V) system by means of the formulae presented in *Cape Mimeogram* No. 3:

$$V = SPv + 0.08\ SCI - 0.06,$$
$$B - V = 0.85\ SCI + 0.26.$$

As no too blue stars are considered, the error expected from the use of these linear relations will be insignificant. According to the CPC the probable errors amount to $\pm^{m}.04$ for V and $\pm^{m}.05$ for $(B-V)$.

To obtain blue and yellow magnitudes for a larger number of stars in the region, a photographic (IAZ) and a photovisual (103a-D) plate were exposed simultaneously in two cameras mounted side by side on the Cape astrographic refractor. The exposure time was 15 minutes. Both plates were measured at Leiden in the Sartorius iris photometer.

The photoelectric and photographic data on the (B, V) system already obtained served for the calibration of the measurements of 57 stars. For some stars the value of $(B - V)$ is missing in Table 1, indicating that B was beyond the range of the calibration curve, and so exceeds a value of 11.3. As only two plates were measured and no corrections for distance from the plate centre were applied, values of V and $(B - V)$ derived in this way are given with one decimal figure only.

3. *The proper motions and radial velocities*

As a first step proper motions were derived by combining the GC positions at the GC epoch with other available meridian observations, following the same procedure as that applied by MORGAN (1952) for the N30 catalogue.

The following meridian catalogues were used:

Cape 1st 25 (*First Cape Catalogue of Stars for the Equinox of* 1925.0, 1928).

La Plata XII (*Observatorio Astronomico de la Universidad Nacional de La Plata, Publicaciones*, Vol. 12, 1936).

Cape 2nd 25 (*Second Cape Catalogue of Stars for the Equinox of* 1925.0, 1949).

Cape 1st 50 (*First Cape Catalogue of Stars for the Equinox of* 1950.0, 1953).

The meridian observations were reduced to the equinox of 1950.0 using NEWCOMB's constants, and systematic corrections were applied to reduce the catalogues to the N30 system. For this purpose use was made of the corrections presented by BERTIAU (1958). The GC positions were reduced to their mean epoch by means of the GC proper motions and, as recommended in the introduction to the N30 catalogue, systematic corrections were applied.

New proper motions were derived from these corrected meridian positions and the corrected GC position by least-squares solutions. Their probable errors were computed according to the formula:

$$\text{p.e.} = \frac{\pm 0''.30 \sqrt{\sum w}}{\sqrt{\sum w . \sum wj^2 - (\sum wj)^2}},$$

where w is the weight given in the N30 to each catalogue and j is the number of years between the GC epoch and the epoch of observation in the meridian catalogues.

The proper motions obtained in this way were combined with the GC proper motions and those given in the CPC into weighted means, the system of N30 being retained. Finally, precessional corrections were applied according to MORGAN and OORT (1951).

It has to be remarked that the great majority of the stars involved only occurs in the CPC, so that 41 out of the 67 proper motions were simply taken from this catalogue, transformed from the FK3 to the N30 system and corrected for precessional effects. All the systematic corrections applied in the course of the computation do not differ significantly from one star to another, and as we are mainly interested in relative proper motions and not in absolute ones, these corrections do not influence our final results.

Radial velocities for 8 stars in IC 2602 were taken from WILSON's (1953) catalogue, while for 2 others more recent estimates are given by FEAST, THACKERAY and WESSELINK (1955).

The data reported on in sections 2 and 3 are assembled in Table 1. The columns represent the following:

Column 1: A running number.
2: The HD or HDE number.
3, 4: The visual magnitude V and the colour-index $(B - V)$, both on the JOHNSON-MORGAN (1953) system.
5: The colour-index $(U - B)_c$, on the system of *Cape Mimeogram* No. 11 (1961).
6: The number of photoelectric observations.
7: The HD spectral type.
8: The spectral type based on WHITEOAK (1961).
9: The spectral class derived by means of the Q_c method.
10, 11: The annual proper motion in R.A. and Decl. (unit $''.001$).
12, 13: The probable error of the proper motion in R.A. and Decl. (unit $''.001$).
14: The radial velocity (in km/sec) as given by WILSON (1953), or estimated by FEAST, THACKERAY and WESSELINK (1955), if it is followed by the mean error placed in brackets.
15: Notes.

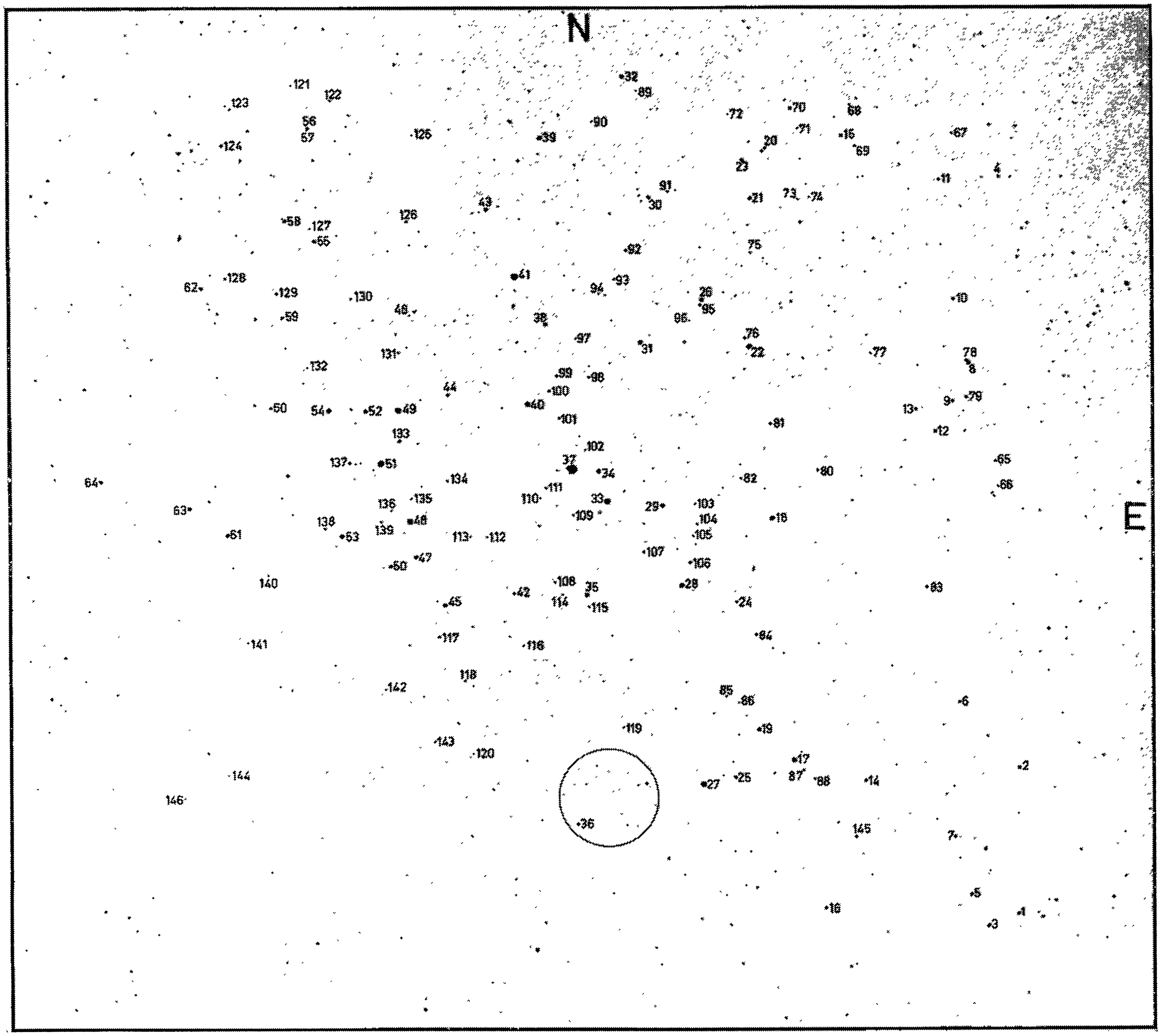
TABLE I

Star	HD, HDE	V	$B-V$	$(U-B)_c$	n	Sp HD	Sp W	Sp Q_c	$15\,\mu_\alpha \cos\delta$	μ_δ	p.e. $15\,\mu_\alpha \cos\delta$	p.e. μ_δ	v_r	Notes
1	91698	8.02	+0.01	1.31	3	B8	—	B5	− 2	− 9	4	4	—	—
2	91711	8.97	+0.29	—	—	B8	—	—	+ 3	−10	5	5	—	—
3	91797	8.91	+0.58	—	—	G0	—	—	−36	+39	4	4	—	—
4	91838	9.83	+0.18	—	—	A0	—	—	−24	−12	13	13	—	—
5	91839	8.39	+0.19	1.56	4	A2	—	—	−21	+22	5	5	—	—
6	91895	9.55	+0.52	—	—	G0	—	—	− 4	+13	7	7	—	—
7	91896	8.88	+0.12	—	—	B8	—	—	+10	+12	4	4	—	—
8	91906	7.34	+0.05	1.50	7	A0	—	A0	− 6	+ 4	4	3	—	1
9	91944	8.68	+0.05	—	—	A0	—	—	−17	−19	3	3	—	(W)
10	91959	9.24	+0.20	1.40	4	B9	—	B6	—	—	—	—	—	—
11	91996	9.45	+0.34	—	—	A0	—	—	−15	−66	12	12	—	—
12	91997	8.95	+0.04	—	—	A0	—	—	−12	− 3	4	4	—	(W)
13	92066	8.40	0.00	—	—	B9	—	—	− 3	− 3	6	6	—	(W)
14	92175	8.78	+1.20	2.16	4	K0	—	—	—	—	—	—	—	—
15	92275	9.13	+0.17	—	—	B8	—	—	+17	−10	7	7	—	—
16	92276	9.34	+0.57	—	—	F2	—	—	−11	+39	8	8	—	2
17	92385	6.74	−0.07	1.37	4	B8	B9 V	B8	− 6	− 3	3	3	—	—
18	92467	6.98	+0.03	1.46	4	B9	B9 IV	B9.5	− 5	+ 5	3	3	—	3
19	92478	7.56	+0.05	1.53	4	A0	A0 IV	A1	−14	+ 4	4	4	—	—
20	92492	9.27	+0.12	—	—	A0	A0 IV	—	− 3	−24	7	7	—	(W)
21	92535	8.26	+0.24	1.56	4	A5	A3 V	—	−29	+11	7	7	—	—
22	92536	6.32	−0.07	1.37	4	B9	B8 IV	B8	− 6	− 1	3	3	—	—
23	92568	8.58	+0.42	—	—	F0	A7p	—	+26	−27	7	7	—	(W)
24	92569	9.46	+0.25	1.55	4	A0	B9.5 IV	A0	+ 8	+22	7	7	—	—
25	92570	8.86	+0.47	—	—	F5	F7 V	—	− 7	+ 3	6	6	—	(W)4
26	92663	7.80	+1.54	2.43	4	K0	—	—	− 1	+ 9	7	7	—	—
27	92664	5.50	−0.16	1.26	4	A0p	B9p	B5	−12	+ 3	4	3	+29.7b	—
28	92715	6.82	−0.03	1.43	4	B9	B9.5 V	B9	− 9	− 8	3	3	—	—
29	92783	6.72	−0.05	1.40	4	B5	B8 V	B9	−11	+ 4	3	3	+21(4)	5
30	92821	8.87	+1.28	—	—	K2	—	—	+ 3	−37	7	7	—	(W)
31	92837	7.17	0.00	1.46	4	B9	B9 V	A0	− 1	− 3	3	3	—	—
32	92896	7.30	+0.22	1.56	4	A5	A5 IV	—	−11	− 9	4	3	—	6
33	92938	4.80	−0.14	1.27	4	B3	B3 V	B5	−13	+14	3	2	+24.2b	7
34	92966	7.26	0.00	1.46	4	B9	B9.5 V	A0	−12	+21	3	3	—	—
35	92989	7.60	+0.04	1.52	4	A0	A1 IV	A1	−19	−20	5	5	—	—
36	93012	9.26	+0.33	1.57	4	A2	—	—	−11	+11	8	8	—	—
37	93030	2.75	−0.23	1.11	4	B0	B0 V	B1	−11	+13	2	2	+24d	8
38	93098	7.60	+0.04	1.53	4	A0	A0 V	—	−13	− 6	4	3	—	—
39	93115	7.85	+1.52	—	—	K5	—	—	+34	− 4	7	7	—	(W)
40	93163	5.76	+0.01	1.30	4	B3	B3 V	B5	0	+ 2	3	3	+8c	9
41	93194	4.82	−0.14	1.26	4	B3	B5 V	B5	− 7	+12	2	2	+25.5b	10
42	93209	9.38	+0.37	1.59	4	A	A4 IV	—	− 6	0	7	7	—	—
43	93269	8.16	+1.16	2.12	4	K0	—	—	− 4	−27	7	7	—	—
44	93405	9.16	+0.44	1.58	4	G0	F2 V	—	−32	+12	8	8	—	—
45	93424	8.12	+0.18	1.58	4	A2	A4 IV	—	−19	− 5	4	4	—	—
46	93505	8.91	+1.62	2.60	4	K5	—	—	− 7	+ 1	4	4	—	—
47	93517	7.84	+0.11	1.56	4	A	A2 V	—	−10	0	4	4	—	—
48	93540	5.34	−0.10	1.31	4	B5	B6 V	B7	−14	+ 1	4	3	+32.4b	11
49	93549	5.23	−0.08	1.31	4	B8	B7 IV	B7	− 1	+ 8	2	2	+21.3b	—
50	93600	8.42	+0.55	1.59	4	G0	F7 V	—	−74	+ 6	6	6	—	—
51	93607	4.86	−0.15	1.26	4	B5	B4 V	B5	−11	+ 4	3	2	+16c	12
52	93648	7.84	+0.13	1.55	4	A0	A2 V	—	− 8	+ 3	3	3	—	—

Table I (*continued*)

Star	HD, HDE	V	$B-V$	$(U-B)_c$	n	Sp HD	Sp W	Sp Q_c	$15\,\mu_\alpha \cos\delta$	μ_δ	p.e. $15\,\mu_\alpha \cos\delta$	p.e. μ_δ	v_r	Notes
53	93714	6.53	+0.03	1.28	4	B3	B2 IV	B3	−16	+9	3	3	−1(4)	13
54	93738	6.46	+0.02	1.43	4	A0	A0 V	B9	−6	+6	3	3	—	—
55	93777	8.50	+1.21	2.14	4	K0	—	—	−35	−9	4	4	—	—
56	93796	10.28	+0.63	—	—	G0	G2 IV	—	—	—	—	—	—	(W)
57	—	9.94	+0.58	—	—	—	F8 V	—	—	—	—	—	—	(W) 14
58	93874	8.18	+0.18	1.57	4	A0	—	A1	−5	+4	4	4	—	—
59	93892	8.99	+0.50	—	—	F5	—	—	−62	−30	7	7	—	(W)
60	93925	9.23	+0.18	—	—	A0	—	—	−26	−14	14	14	—	—
61	94066	7.86	+0.11	1.33	4	B5	—	B3	−8	+1	4	4	—	—
62	94115	8.84	+1.32	2.21	4	K0	—	—	—	—	—	—	—	—
63	94174	7.74	+0.11	1.54	4	A0	—	A1	+1	0	4	4	—	—
64	94422	8.24	+0.10	—	—	B9	—	—	−17	−8	3	3	—	(W)
65	307805	10.1	+0.4	—	—	A3	—	—	—	—	—	—	—	—
66	307806	10.8	+0.2	—	—	A0	—	—	—	—	—	—	—	—
67	307840	10.1	+1.1	—	—	G5	—	—	—	—	—	—	—	—
68	307841	10.4	+0.2	—	—	A0	—	—	—	—	—	—	—	—
69	307842	9.42	+0.76	1.84	2	G5	—	—	—	—	—	—	—	—
70	307844	9.30	+1.41	—	—	K6	—	—	—	—	—	—	—	(W)
71	307845	10.9	—	—	—	G	—	—	—	—	—	—	—	—
72	307846	10.9	+0.2	—	—	A2	—	—	—	—	—	—	—	—
73	307848	10.8	+0.2	—	—	A0	—	—	—	—	—	—	—	—
74	307849	10.48	+0.48	1.64	2	F1	—	—	—	—	—	—	—	—
75	307852	10.6	+0.1	—	—	B8	—	—	—	—	—	—	—	—
76	307856	10.58	+1.22	—	—	K0	—	—	—	—	—	—	—	(W)
77	307859	10.35	+0.20	—	—	A0	—	—	—	—	—	—	—	(W)
78	307860	8.24	+0.22	—	—	A0	—	—	+1	−5	4	4	—	(W) 15
79	307861	10.01	+0.50	—	—	A5	—	—	—	—	—	—	—	(W)
80	307868	9.8	+1.2	—	—	K0	—	—	—	—	—	—	—	—
81	307869	9.4	—	—	—	K7	—	—	—	—	—	—	—	—
82	307872	10.4	0.0	—	—	A0	—	—	—	—	—	—	—	—
83	307876	9.0	+1.8	—	—	K2	—	—	—	—	—	—	—	—
84	307880	9.8	+1.4	—	—	K0	—	—	—	—	—	—	—	—
85	307882	10.6	+0.1	—	—	B9	—	—	—	—	—	—	—	—
86	307883	10.9	—	—	—	A0	—	—	—	—	—	—	—	—
87	307886	9.9	+1.2	—	—	K2	—	—	—	—	—	—	—	—
88	307887	9.9	+0.3	—	—	A2	—	—	—	—	—	—	—	—
89	307917	10.9	+0.3	—	—	A0	—	—	—	—	—	—	—	—
90	307918	10.9	—	—	—	A3	—	—	—	—	—	—	—	—
91	307919	10.06	+1.14	—	—	G5	—	—	—	—	—	—	—	(W)
92	307921	9.04	+1.58	—	—	K5	—	—	—	—	—	—	—	(W)
93	307922	9.99	+0.60	—	—	F5	—	—	—	—	—	—	—	(W)
94	307924	10.70	+0.62	—	—	F8	—	—	—	—	—	—	—	(W)
95	307926	9.70	+1.34	—	—	K0	—	—	—	—	—	—	—	(W)
96	307927	9.4	+1.7	—	—	K2	—	—	—	—	—	—	—	—
97	307929	10.6	—	—	—	G5	—	—	—	—	—	—	—	—
98	307931	10.11	+1.21	—	—	K5	—	—	—	—	—	—	—	(W)
99	307933	8.90	+0.43	—	—	A3	—	—	—	—	—	—	—	(W)
100	307934	10.08	+1.63	—	—	K7	—	—	—	—	—	—	—	(W)
101	307937	9.76	+0.11	—	—	A0	—	—	—	—	—	—	—	(W)
102	307938	10.5	+0.5	—	—	G0	—	—	—	—	—	—	—	—
103	307941	10.4	0.0	—	—	B9	—	—	—	—	—	—	—	—

FIGURE 1



Stars observed in IC 2602. Numbers are those of column 1 of Table 1.
The circle indicates the position of the more distant cluster Mel 101. The scale is 53″/mm.

TABLE I (*continued*)

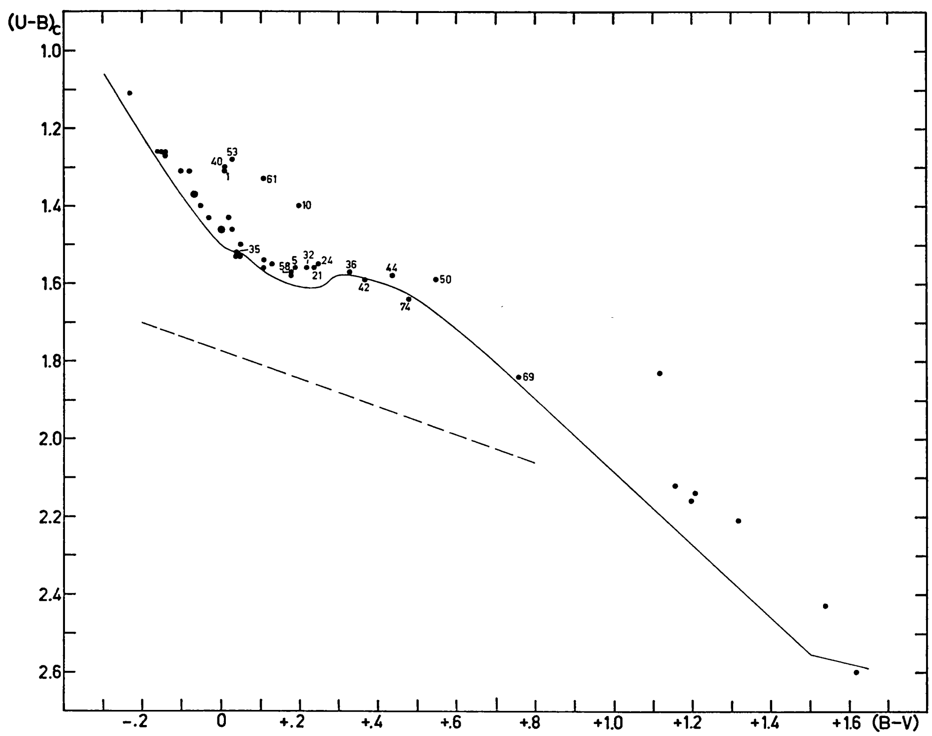
Star	HD, HDE	V	$B-V$	$(U-B)_c$	n	Sp			$15\,\mu_\alpha \cos\delta$	μ_δ	p.e.		v_r	Notes
						HD	W	Q_c			$15\,\mu_\alpha \cos\delta$	μ_δ		
104	307942	9.9	+0.7	—	—	F2	—	—	—	—	—	—	—	—
105	307943	10.8	+0.5	—	—	A2	—	—	—	—	—	—	—	—
106	307944	9.3	+1.5	—	—	K0	—	—	—	—	—	—	—	—
107	307948	9.7	0.0	—	—	A0	—	—	—	—	—	—	—	—
108	307949	10.5	—	—	—	G5	—	—	—	—	—	—	—	—
109	307951	10.5	—	—	—	G5	—	—	—	—	—	—	—	—
110	307953	10.6	+0.2	—	—	B5	—	—	—	—	—	—	—	—
111	307954	10.4	0.0	—	—	A0	—	—	—	—	—	—	—	—
112	307955	10.8	—	—	—	G5	—	—	—	—	—	—	—	—
113	307956	10.9	—	—	—	F5	—	—	—	—	—	—	—	—
114	307957	10.6	—	—	—	M	—	—	—	—	—	—	—	—
115	307958	10.73	+0.18	—	—	B9	—	—	− 4	0	8	8	—	—
116	307959	10.8	—	—	—	G0	—	—	—	—	—	—	—	—
117	307963	10.06	+1.15	—	—	K0	—	—	—	—	—	—	—	(W)
118	307964	10.12	0.00	—	—	B9	—	—	+ 7	+16	7	7	—	—
119	307969	10.8	—	—	—	F2	—	—	—	—	—	—	—	—
120	307979	10.9	—	—	—	G0	—	—	—	—	—	—	—	—
121	308001	10.9	+0.2	—	—	B5	—	—	—	—	—	—	—	—
122	308002	10.4	0.0	—	—	A0	—	—	—	—	—	—	—	—
123	308003	10.1	—	—	—	K0	—	—	—	—	—	—	—	—
124	308004	8.8	+2.0	—	—	K7	—	—	—	—	—	—	—	—
125	308005	10.6	+0.5	—	—	A3	—	—	—	—	—	—	—	—
126	308006	9.78	+1.53	—	—	M0	—	—	− 8	− 9	4	4	—	(W)
127	308007	10.8	+0.5	—	—	A3	—	—	—	—	—	—	—	—
128	308008	9.7	+0.5	—	—	A5	—	—	—	—	—	—	—	—
129	308009	10.2	+0.2	—	—	A0	—	—	—	—	—	—	—	—
130	308010	10.6	+0.2	—	—	A3	—	—	—	—	—	—	—	—
131	308012	10.06	+0.49	—	—	F8	—	—	—	—	—	—	—	(W)
132	308013	10.4	+0.6	—	—	G	—	—	—	—	—	—	—	—
133	308015	8.95	+1.19	—	—	G5	—	—	+27	+17	7	7	—	(W)
134	308016	10.5	—	—	—	G5	—	—	—	—	—	—	—	—
135	308017	10.9	—	—	—	A0	—	—	—	—	—	—	—	—
136	308018	10.8	—	—	—	K0	—	—	—	—	—	—	—	—
137	308021	9.4	—	—	—	K5	—	—	—	—	—	—	—	—
138	308023	10.13	+0.18	—	—	B8	—	—	− 3	− 4	8	8	—	—
139	308024	10.4	0.0	—	—	B9	—	—	—	—	—	—	—	—
140	308025	10.8	—	—	—	F2	—	—	—	—	—	—	—	—
141	308027	10.2	+0.3	—	—	B9	—	—	—	—	—	—	—	—
142	308028	10.6	—	—	—	K7	—	—	—	—	—	—	—	—
143	308030	10.1	+0.5	—	—	A3	—	—	—	—	—	—	—	—
144	308031	9.8	+1.3	—	—	K2	—	—	—	—	—	—	—	—
145	310105	11.14	+1.12	1.83	2	G5	—	—	—	—	—	—	—	—
146	310227	10.95	+0.34	—	—	A2	—	—	− 5	− 9	8	8	—	—

Notes referred to in column 15 are as follows:

(W). V and $(B-V)$ taken from WHITEOAK (1961).

1. No. 8. Component of a triple system (No. 8 + No. 78). INNES (1927) (further on referred to as I) estimates its magnitude in the HD scale to be 7.8.
2. No. 16. Multiple (I: 9.6, 9.7, 8.9, 9.1).
3. No. 18. Binary (I: 6.7, 8.2).
4. No. 25. Binary (I: 9.1, 9.8).
5. No. 29. B9 V n (FEAST, THACKERAY and WESSELINK 1955).
6. No. 32. Binary (I: 8.6, 8.8).
7. No. 33. B3 V (WOODS 1955).
8. No. 37. θ Car. O9.5 V (DE VAUCOULEURS 1957). B0 V p (WOODS).
9. No. 40. B3: V (DE VAUCOULEURS).
10. No. 41. B5 V n (DE VAUCOULEURS. B3 V (WOODS).
11. No. 48. B7: V (DE VAUCOULEURS).
12. No. 51. B4 IV (DE VAUCOULEURS).
13. No. 53. B3 III (FEAST, THACKERAY and WESSELINK).
14. No. 57. Component of a close double (No. 56 + No. 57).
15. No. 78. Binary (I: 8.5, 10.7).

FIGURE 2



Two-colour-index diagram for IC 2602. The full line represents the standard $(B-V)$, $(U-B)_c$ relation, and the dashed line indicates the slope of the reddening line according to COUSINS, EGGEN and STOY (1961). The figures next to the dots are running numbers.

4. *Discussion of the observations*

The two-colour-index diagram, for which only photoelectric data are available, is given in Figure 2. The full line in this figure is the intrinsic position of the main sequence and the broken line indicates the slope of the reddening line, $\frac{E_{(U-B)_c}}{E_{(B-V)}} = 0.36$, according to COUSINS, EGGEN and STOY (1961). In this and the following figures coinciding points are indicated by larger dots; some stars are indicated by their numbers.

It is at once apparent that little interstellar reddening is present in the case of IC 2602. The five stars well detached from the main sequence, between $(B-V) = 0.0$ and $+0.2$, will prove to be reddened stars not belonging to the cluster.

For the stars observed photoelectrically at the Cape and classified as A1 or earlier, the visual magnitudes corrected for interstellar absorption, V_0, and the colours corrected for interstellar reddening, $(B-V)_0$, were computed according to the relations (COUSINS, EGGEN and STOY 1961):

$$Q_c = (U-B)_c - 0.36\,(B-V)\ ,\quad (B-V)_0 = 0.87\,Q_c - 1.32\,,$$
$$E_{(B-V)} = (B-V) - (B-V)_0\ ,\quad V_0 = V - 3\,E_{(B-V)}\,.$$

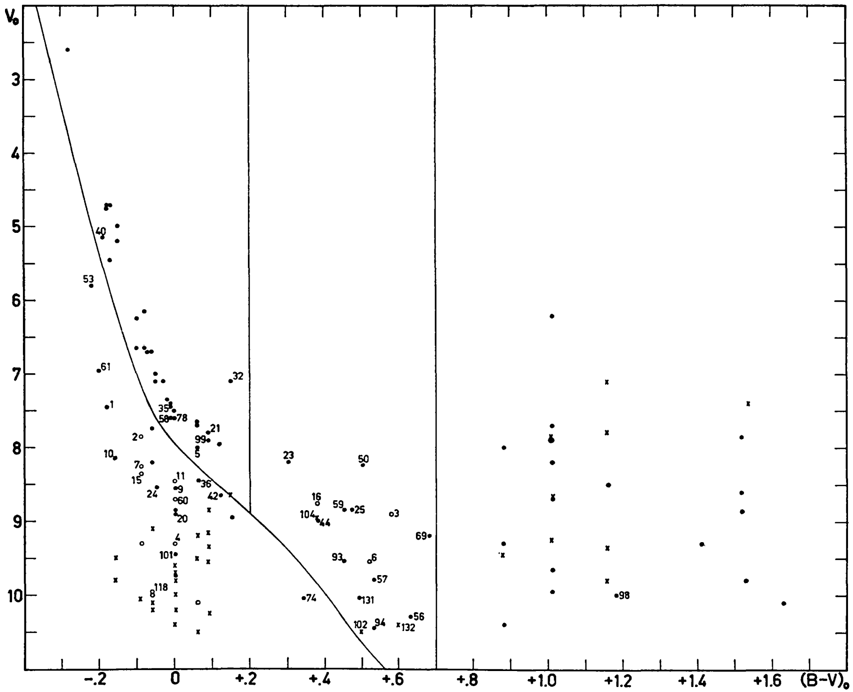
Q_c may be considered as an equivalent of spectral class in the interval OB—A1, and the spectral types given in column 9 of Table 1 were derived from Q_c making use of the (Q_c, MK-type) relation presented by COUSINS, EGGEN and STOY (1961). The types determined in this way are in good agreement with the Draper types and those given by WHITEOAK.

For the computation of the colour excesses of the remaining stars, $(B-V)_0$ was taken from JOHNSON's (1958) and ARP's (1958) tables of intrinsic colours, using the available spectral classes. Stars of spectral type G5 or later were supposed to be of luminosity class III, except Nos. 69 and 98, as their observed colours $(B-V)$, if they are giants, are smaller than $(B-V)_0$.

The colour-magnitude diagram representing both the photoelectrically and the photographically observed stars, corrected for the effects of interstellar reddening and absorption, is shown in Figure 3. Values derived photoelectrically are plotted as dots, those taken from the CPC as circles and those measured photographically at Leiden as crosses.

We shall separately discuss the stars in four divisions of this diagram. A first group consists of the stars to the left of the curve in the figure, a second appears to

FIGURE 3



Colour-magnitude diagram. Stars observed photoelectrically are plotted as dots, values taken from the CPC as circles and those measured photographically at Leiden as crosses. Lines divide the diagram into four parts, separately discussed in the text.

the right of the curve and at $(B-V)_0 < +0.2$, a third between $(B-V)_0 = +0.2$ and $+0.7$ and a fourth at $(B-V)_0 > +0.7$.

We first consider the proper motions. These are plotted in Figure 4. Radial velocities are indicated by numbers in the same figure, plus signs for the positive velocities being omitted.

The distribution of the proper motions exhibits an obvious concentration. For a star to belong to IC 2602 we have set as a condition that its proper motion is inside the circle, with a radius of ″.018, drawn in the figure. It should be noted, however, that it is difficult to distinguish between cluster members and background objects by their proper motions. The reflex of the solar motion at the distance of the cluster is indicated by a cross in Figure 4.

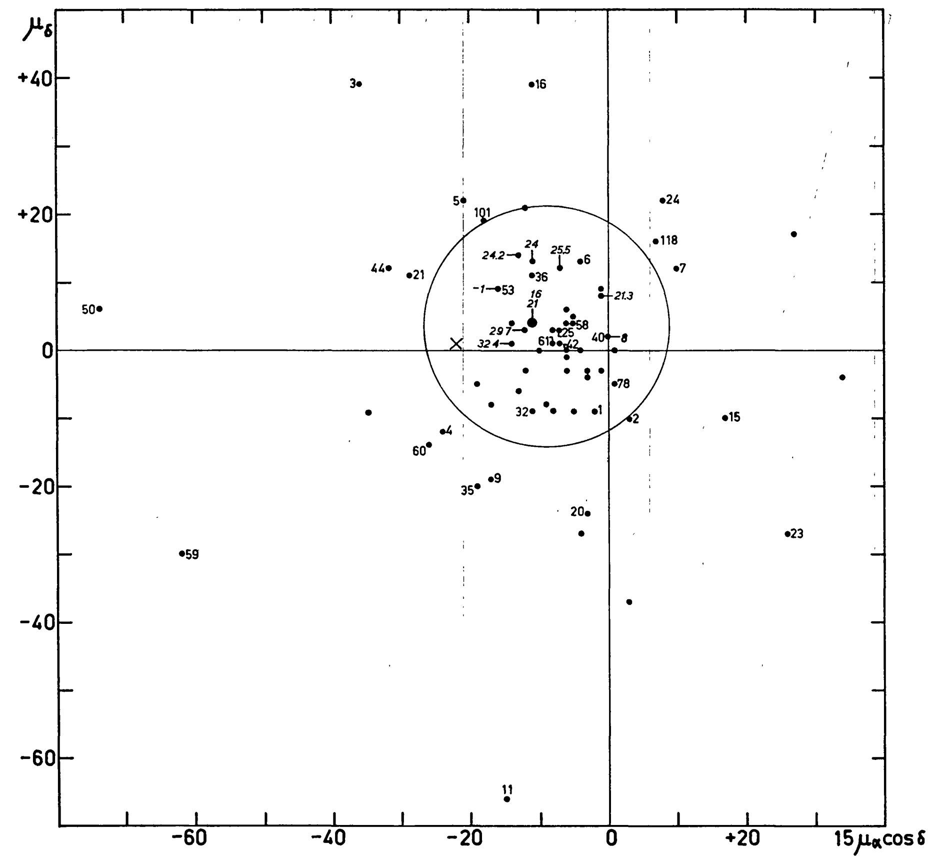
The radial velocities too exhibit little scatter. Only stars Nos. 40 and 53 have strongly deviating velocities (+ 8 and − 1 km/sec) and for this reason will be excluded from the list of cluster members.

The stars to the right of the line in the colour-magnitude plot and at $(B-V)_0 < +0.2$ are arranged along the main sequence. This indicates that the great majority of these stars belongs to the cluster. This is also in agreement with the arrangement of most of these stars along the intrinsic line of the colour-colour diagram of Figure 2. The proper motions of 26 stars out of the 30 situated in this part of the colour-magnitude diagram fall inside the circle in Figure 4. Because of its strongly deviating radial velocity and its position in Figure 2, star No. 40 is certainly a background star. Stars Nos. 5, 21, 32, 35, 58, 78 and 99 may be considered as possible members. Nos. 5, 21 and 35 have deviating proper motions and for Nos. 58, 78 and 99 the amount of interstellar absorption $A_V = 3\ E_{(B-V)}$ considerably exceeds the value of A_V for the well established members. No. 32 is a binary situated above the main sequence.

The stars plotted to the left of the curve in the colour-magnitude diagram are almost certainly background objects, as most of them are situated at least $^{m}.5$ below the main sequence. Stars Nos. 2, 4, 7, 9, 11, 15, 20, 24, 60, 101 and 118 have proper motions outside the circle and, as already mentioned, the two-colour-index diagram yields extra evidence for the non-membership of stars Nos. 1, 10, 53 and 61. Moreover star No. 53 is a binary with a strongly deviating radial velocity. Stars Nos. 24, 36, 42 and 74 occupy a somewhat deviating position in the colour-colour plot.

Most of the stars between $(B-V)_0 = +0.2$ and $+0.7$ are above the main sequence and therefore are either foreground objects or cluster members in the pre-main sequence stage. The proper motions of stars Nos. 3, 16, 23, 44, 50 and 59 are extremely large, from which we may conclude that they are fore-

FIGURE 4



Proper motions of stars in the field of IC 2602. Unit ″.001. Cluster members have their proper motion plotted inside the circle (radius ″.018). The italicized numbers refer to radial velocities. A cross indicates the reflex of the solar motion at a distance of 155 pc.

ground objects. Stars Nos. 6, 25, 56, 57, 69, 93, 94, 102, 104, 131 and 132 may belong to the group. For 7 out of the 17 stars in this part of the diagram, the observed $(B-V)$ is too small for their spectral types. Some evidence of the non-membership of stars Nos. 3, 6, 16, 23, 25, 56, 57 and 69 is given by their position at the outskirts of the cluster.

Finally, most of the stars with $(B-V)_0 > +0.7$ are very probably background giants, judging from their position in Figures 2 and 3.

5. *The colour-magnitude diagram*

Table 2 contains V_0, $(B-V)_0$ and A_V for the stars which according to the preceding section may be classified as members of the cluster, or possibly belong to it. The latter are marked by an asterisk. Less accurately derived values are placed in parentheses. The mean value of A_V for the certain members is $^m.16$.

The magnitudes V_0 and the colours $(B-V)_0$ are plotted in Figure 5, where dots represent the certain members and circles the doubtful ones. The full line in this colour-magnitude diagram represents JOHNSON and IRIARTE's (1958) standard zero-age main sequence fitted to the sequence of the points around $(B-V)_0 = 0.0$, where we assume the stars to have not evolved yet. The standard curve had to be displaced vertically by $5^m.95$, yielding a distance of 155 pc for the cluster. A similar value was derived by WHITEOAK (1961). Previous distance determinations (ALTER, RUPRECHT and VANYSEK 1958) range from 160 to 220 pc. With a distance of 155 pc the diameter of IC 2602 is found to be about 5 pc.

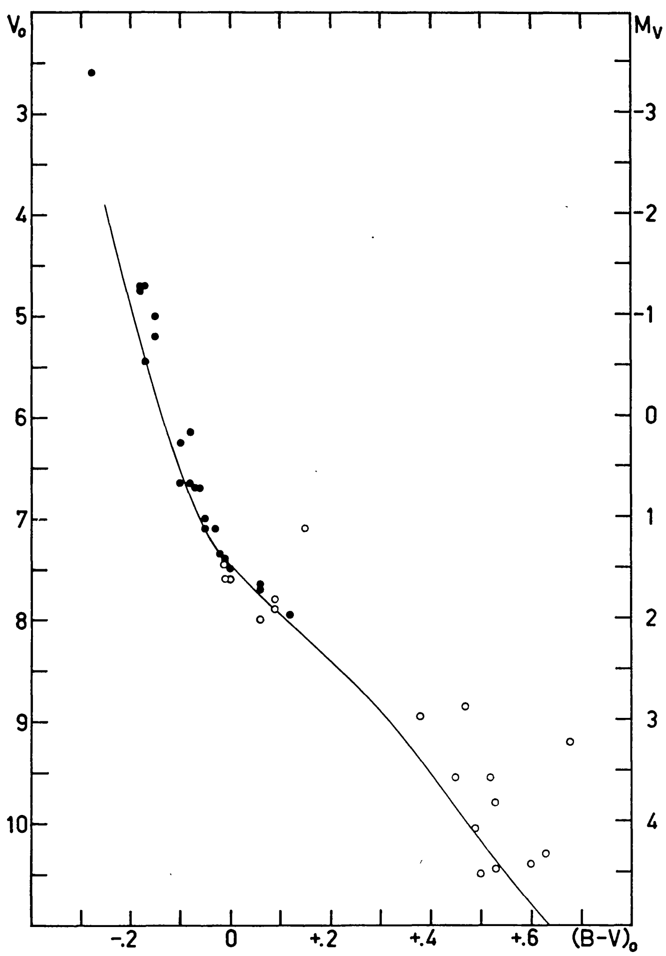
The absolute magnitude M_V of the brightest cluster member, θ Car, is -3.3. Thus, according to SANDAGE (1958), the "nuclear" age of the cluster is about 8×10^6 years. If on the other hand we suppose the stars below $M_V = +1.8$ not yet to have reached the main sequence, as is suggested by Figure 5, we find with SANDAGE (1958) again about 8×10^6 years for the "gravitational contraction" age of the group. This agreement suggests that very probably the pre-main sequence branch sets in around $(B-V)_0 = +0.05$, and therefore it is not excluded that some of the stars mentioned in section 4 are indeed in the stage of contracting towards the main sequence.

BS Car, an eclipsing variable of the W Ursae

TABLE 2

Star	V_0	$(B-V)_0$	A_V	Star	V_0	$(B-V)_0$	A_V	Star	V_0	$(B-V)_0$	A_V
5*	8.00	+0.06	0.39	33	4.71	−0.17	0.09	56*	(10.28)	(+0.63)	(0.00)
6*	(9.55)	(+0.52)	(0.00)	34	7.11	−0.05	0.15	57*	9.79	+0.53	0.15
8	7.10	−0.03	0.24	35*	7.45	−0.01	0.15	58*	7.61	−0.01	0.57
17	6.65	−0.10	0.09	37	2.60	−0.28	0.15	63	7.35	−0.02	0.39
18	6.71	−0.06	0.27	38	7.48	0.00	0.12	69*	9.18	+0.68	0.24
19	7.38	−0.01	0.18	41	4.70	−0.18	0.12	78*	7.58	0.00	0.66
21*	7.81	+0.09	0.45	45	7.94	+0.12	0.18	93*	9.54	+0.45	0.45
22	6.23	−0.10	0.09	47	7.69	+0.06	0.15	94*	10.43	+0.53	0.27
25*	(8.86)	(+0.47)	(0.00)	48	5.19	−0.15	0.15	99*	7.88	+0.09	1.02
27	5.47	−0.17	0.03	49	5.02	−0.15	0.21	102*	(10.50)	(+0.50)	(0.00)
28	6.70	−0.07	0.12	51	4.77	−0.18	0.09	104*	8.94	+0.38	0.96
29	6.63	−0.08	0.09	52	7.63	+0.06	0.21	131*	(10.06)	(+0.49)	(0.00)
31	7.02	−0.05	0.15	54	6.16	−0.08	0.30	132*	(10.40)	(+0.60)	(0.00)
32*	7.09	+0.15	0.21								

FIGURE 5



Colour-magnitude array for IC 2602. Dots represent certain cluster members, circles represent possible ones. The line represents the zero-age main sequence according to JOHNSON and IRIARTE (1958). The absolute magnitude scale is given to the right of the figure.

Majoris type, was mentioned by SAHADE and FRIEBOES (1960) as a possible member of IC 2602. Besides its rather great distance from the centre of the cluster, its maximum brightness of only $14^m.7$ militates against its membership of the group. No spectral classification is available for the star, but usually the spectral types of the components of W Ursae Majoris variables range from F to K. From this we may conclude that BS Car is a background star.

6. *Peculiar motions*

Excluding the stars in Table 2 denoted as doubtful members of the cluster, we find from the 22 remaining ones the following mean values for the proper motion components $15\,\mu_\alpha \cos\delta$ and μ_δ:

$$\overline{15\,\mu_\alpha \cos\delta} = -\,{}^{''/a}.0088 \pm {}^{''/a}.0010 \text{ (m.e.)},$$
$$\overline{\mu_\delta} = +\,{}^{''/a}.0035 \pm {}^{''/a}.0015 \text{ (m.e.)}.$$

The distance of the cluster being 155 pc, these values expressed in km/sec are:

$$\overline{15\,\mu_\alpha \cos\delta} = -\,6.46 \text{ km/sec} \pm 0.73 \text{ km/sec (m.e.)},$$
$$\overline{\mu_\delta} = +\,2.57 \text{ km/sec} \pm 1.10 \text{ km/sec (m.e.)}.$$

The mean radial velocity $\overline{v_r}$ determined from 8 stars is:

$$\overline{v_r} = +\,24.26 \text{ km/sec} \pm 1.80 \text{ km/sec (m.e.)}.$$

From these values the space velocity of the cluster with respect to the sun is found to be 25.2 km/sec ± 1.7 km/sec (m.e.). After removal of the standard solar motion (20 km/sec towards R.A. 18^h, Decl. + 30°) and elimination of differential galactic rotation this amounts to 19.3 km/sec.

The mean-square deviations are:

$\pm\,4.08$ km/sec for $15\,\mu_\alpha \cos\delta$,
$\pm\,5.90$ km/sec for μ_δ,
and $\pm\,4.81$ km/sec for v_r.

As best estimate of the mean-square deviation in one component we obtain

$$\sigma_1 = 5.19 \text{ km/sec} \pm 0.51 \text{ km/sec (m.e.)}.$$

The contributions of accidental errors to the observed dispersions are ± 4.19, ± 3.84 and ± 3.32 km/sec in the three co-ordinates respectively. For the mean of the three components this gives

$$\sigma_2 = 4.04 \text{ km/sec} \pm 0.39 \text{ km/sec (m.e.)}.$$

So the true dispersion, or mean peculiar motion in one component, amounts to

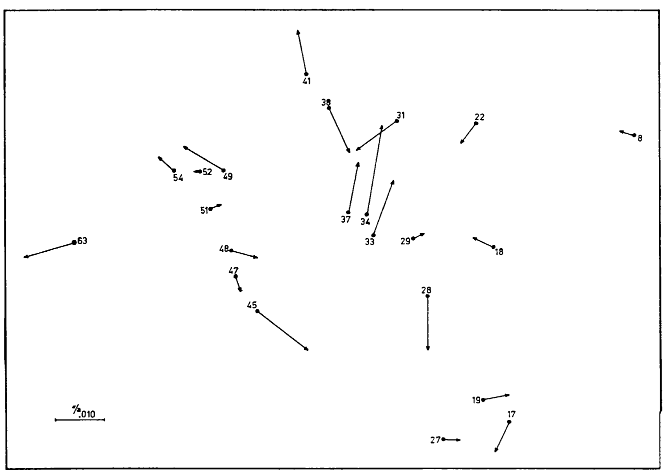
$$\sigma = (\sigma_1^2 - \sigma_2^2)^{1/2} = 3.3 \text{ km/sec} \pm 0.9 \text{ km/sec (m.e.)}.$$

This value of σ is much larger than the value of the peculiar motion following from the virial theorem in case the cluster is stable, and therefore would indicate that IC 2602 is expanding. However, with $\sigma = 3.3$ km/sec and an age of 8×10^6 years for the group, we would find the mean distance of the stars from the centre of the cluster to be of the order of 26 pc, i.e. about 24 times the observed mean radius (1.1 pc). This suggests that the errors have been underestimated and that the internal motion is considerably smaller. If the cluster has a total mass of $M = 100\,m_\odot$ (approximately the total mass of the 22 certain members) and its mean radius is $\overline{R} = 1.1$ pc, we find from the virial theorem:

$$\sigma = \frac{4.63 \times 10^{-2}}{\sqrt{3}} \sqrt{\frac{M}{\overline{R}}} = 0.25 \text{ km/sec.}$$

M may be considerably greater than stated, so that $\sigma = 0.25$ km/sec is only a lower limit.

FIGURE 6



Relative proper motions of the certain cluster members. The scale of the proper motions is in the lower left-hand corner.

Making use of the GC proper motions of 15 stars (2 of which we rejected as cluster members) and placing the distance of IC 2602 at 220 pc, MARKARIAN (1953) found the cluster to be expanding at a rate of about 0.224 km/sec/minute of arc, corresponding to an "expansion" age of 3×10^5 years. The foregoing considerations are in discordance with this result. A computation based on the data derived in this paper yields a rate of expansion of only 0.033 ± 0.018 (p.e.) km/sec/minute of arc, an insignificant value considering its probable error.

The motions of the certain cluster members relative to the mean motion of the group are shown in Figure 6, confirming their accidental character.

The author wishes to express his gratitude to Prof. Dr R. H. STOY for his hospitality and generous help, and for placing the facilities of the Royal Observatory and the unpublished data of the CPC at his disposal. He also is very indebted to Prof. Dr A. BLAAUW for suggesting this work and for his helpful advice.

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