STELLAR GROUPS, VIII. THE STRUCTURE OF THE SIRIUS GROUP

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Summary

One hundred stars with (U, V)-loci that pass within 4 km/sec of $(U, V)=(-14{\cdot}2, -0{\cdot}4)$ are assigned to the Sirius group. The most noteworthy features of the resulting $(M_V, B-V)$-diagram are (*a*) the main sequence of the Sirius group is displaced from that of the Hyades group, ΔM_V (Sirius-Hyades) $= +0^{m}{\cdot}2$, and the main sequence stars with $+0^{m}{\cdot}3 \leqslant B-V < +0^{m}{\cdot}6$ show an ultra-violet excess of $\delta(U-B) = +0^{m}{\cdot}04$ with respect to the Hyades stars, (*b*) the small amplitude, short period light and velocity variable, δ Del, is a group member with luminosity and colour similar to those found for the prototype variable δ Scu in the Hyades group, (*c*) the presence of bluer main sequence stars and brighter G-type giants in the Sirius group indicates that this group is younger than the Hyades group, and (*d*) there are probably very many undiscovered group members near the Sun. The spatial distribution of the group members gives some indication of elongation in the direction of galactic rotation but because of the smallness of the motion and the resulting incompleteness of the group membership, no definite conclusion can be drawn. The mass-luminosity relation for the visual binaries in the group with $M_V > +3^{m}$ deviates from the normal relation in the same way as the Hyades group binaries in this luminosity range; the Sun is one magnitude fainter than Hyades and Sirius group members of the same mass. The binaries with components brighter than $M_V = +3^{m}$, including the eclipsing binaries β Aur and α CrB, indicate that there may *not* be a unique mass-luminosity relation for group stars of this luminosity.

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1. *Members of the Sirius group.*—The first paper of this series (Eggen 1958, Paper I) contained a list of 70 stars selected, by the convergent point method, as members of the Sirius group. Many of these stars have in the past been assigned to the "Ursa Major stream" which appears to share the motion of 6 bright, and 6 fainter, stars in the region of Ursa Major—the so-called "Ursa Major nucleus cluster". Since the Hyades cluster is used to define the motion of the Hyades group (Eggen 1960b, Paper VII), by analogy it might appear reasonable to define the motion of the extended Ursa Major stream by that of the nucleus cluster. However, the position and direction of motion of the nucleus cluster stars cause difficulties in fixing the apparent convergent point of their motion (cf. Petrie and Moyls 1953) and, therefore, the well-determined proper motion, radial velocity and parallax of Sirius, which is known to be a member of the group, were used to define the group motion.

In the previous paper (Paper VII) it was found that the W-motions (perpendicular to the galactic plane) of the Hyades group stars may be uncoupled from the U- (away from the galactic centre) and V- (in the direction of galactic rotation) motions. Therefore the convergent point method of selecting group members discriminates against members whose W-motion differs from that of the Hyades cluster, which defines the group motion. Also, because in the convergent point method the group parallax of each member is computed from the *size* of the proper motion, that parallax will be in error if any of the W-motion is reflected in the observed proper motion and if the W-motion deviates from that of the Hyades stars. The motion criteria for membership in the Hyades group was therefore based on the U- and V-motions alone; those stars for which a (U, V)-match with the Hyades cluster stars, $(U, V) = (+48, -18)$, was possible within ± 3 km/sec in both coordinates were selected as possible members. The median W-motion of the Hyades group members, ~ -4 km/sec, is only a small fraction of the total space motion, 45 km/sec, of the group. On the other hand, the median W-motion of the Sirius group contains a large percentage of the total motion and so a somewhat different procedure than that described for the Hyades group has been used here in selecting possible members.

The space motion vectors of Sirius, relative to the Sun, are as follows:

$$U = -14{\cdot}2 \text{ km/sec};$$
$$V = -0{\cdot}4 \text{ km/sec};$$
$$W = -11{\cdot}8 \text{ km/sec};$$

all vector motions discussed here have been computed to the nearest 0·1 km/sec but are rounded-off to units of 1 km/sec in Table II. The small total space motion of Sirius and group members compared to that of the Hyades group makes the likelihood of including spurious members comparatively greater. This disadvantage is only partly compensated by the fact that the Sirius group motion relative to the Sun is diametrical to that of the bulk of the older population I stars (Eggen 1960a, Paper VI) and lies in the (U, V)-plane near the circumference of the limiting ellipse for that population.

Fig. 1 shows a section of the (U, V)-plane containing Sirius (filled circle). Space motion vectors have been computed, assuming 3 values of the parallax, for (*a*) the stars in Roman's (1949) combined list of all stars assigned at various times to the Ursa Major stream, and (*b*) approximately 500 additional stars selected from the General Catalogue of Radial Velocities (Wilson 1953). The resulting (U, V)-loci of three probable members of the Sirius group are illustrated in Fig. 1 where the points corresponding to various values of the parallax are also indicated. Those stars whose (U, V)-loci pass within 4 km/sec of the point representing Sirius are considered as possible members of the group and the group parallax is taken to be that value which corresponds to the shortest distance between $(U, V) = (-14{\cdot}2, -0{\cdot}4)$ and the (U, V)-locus of the star. This procedure has the advantages that (*a*) the resulting group parallax depends upon both the observed radial velocity and the proper motion, and (*b*) no restriction is placed on the value of W. The dependence of the computed parallax of a group member on the accuracy of the (U, V)-values for Sirius is also apparent in Fig. 1. For example, combined errors in the proper motion, radial velocity and parallax of Sirius that might produce an error of 1 km/sec in U would have relatively little effect on the computed parallax of β Aur but would cause an error of 15 per cent in that of δ Del.

The 100 possible members of the Sirius group chosen in this way are listed in Table I with the following information:

W: Number in Wilson's (1953) radial velocity catalogue.

Name: Alternative identification.

V_E, $B-V$, $U-B$: Magnitudes and colours mainly by Johnson and Knuckles (1957), Stoy (1953), Naur (1955), and Eggen (1955, and unpublished). No colours are available for a few of the stars; the values of $(U-B)_C$ determined with the Cape refractor are given in parentheses.

Sp: Spectral types on the MK system are mainly by Roman (1949), Slettebak (1954, 1955) or de Vaucouleurs (1957); the remaining are mainly from the radial velocity catalogue (Wilson 1953).

μ_α, μ_δ, S: The proper motion and its source. The references consulted in forming the mean values are as follows:

1. GC.
2. N30.
3. FK3 and supplements.
4. Second Greenwich Catalogue for 1925.
5. G. van Herk, *Leiden Annals*, **18**, 1957.
6. J. Robertson, *Washington Zodiacal Catalogue*, 1940.
7. Yale Zone Catalogues.

Notes: The notes pertain mainly to known companions.

The group parallaxes are listed in Table II together with the resulting luminosities and space motions.

TABLE I

Probable members of the Sirius group

W	Name	V_E	$B-V$	$U-B$	Sp	ρ Q	μ_α	μ_δ	S
		m	m				″	″	
164	σ And	4·53	+0·05	+0·06	A2 V	− 8·0 b	−0·067	−0·038	1, 2
228	44 Psc	5·8:	+0·80	...	gG5	− 4·1 b	−0·016	−0·012	1+, 2, 3
378	μ Phe	4·58	+0·97	...	G8 III	+16·5 a	−0·022	+0·001	1, 2, 3
408	HR 196	5·5	...	...	A2	− 8·5 b	−0·026	+0·004	1, 4
*1019	HD 11131	6·79	+0·63	(+1·71)	dG1	− 2·5 b	−0·137	−0·088	1+
1021	χ Cet	4·62	+0·34	+0·02	F2 V	− 0·9 b	−0·153	−0·088	1, 2, 3
*1106	48 Cas	4·50	+0·18	...	A4 V	− 5·0 c	−0·064	+0·009	1
*1222	HR 647	6·06	+0·40	−0·07	F5 V	− 8·1 b	−0·064	−0·056	1, 5
*1463	υ Cet	4·86	+0·86	+0·53	G5 III	+ 5·0 a	−0·030	−0·021	1, 2, 3
1616	υ Hyi	4·77	+1·36	...	gK4	+ 4·7 a	−0·030	−0·022	1, 2
2197	HR 1195	4·11	+0·96	...	gG8	+ 2·0 a	−0·051	−0·047	1, 2, 3
*2546	ξ Eri	5·17	+0·08	+0·08	A2	− 6·3 c	−0·049	−0·054	1, 2, 3
2871	2 Aur	4·77	+1·41	+1·58	K3 III	−16·5 a	−0·026	−0·008	1, 2, 4
3046	β Eri	2·80	+0·13	+0·10	A3 III	− 8·0 c	−0·094	−0·080	1, 2, 3
*3566	γ Lep B	6·15	+0·94	+0·74	dK5	− 9·7 a	−0·288	−0·372	1, 2, 3
*3567	γ Lep A	3·60	+0·47	−0·03	F6 V	− 9·7 a	−0·288	−0·372	1, 2, 3
3663	χ^1 Ori	4·41	+0·59	+0·06	G0 V	−13·5 a	−0·187	−0·084	1, 6
*3730	β Aur	1·90	+0·03	+0·06	A2 IV	−18·2 a	−0·051	−0·004	1, 2, 3
*4050	δ Col	3·81	+0·88	...	gG6	− 2·6 a	−0·028	−0·056	1, 2
*4079	RR Lyn	5·64	+0·24	+0·12	Am	−12·7 a	−0·019	+0·018	1, 4
*4392	α CMa	−1·46	−0·01	−0·06	A1 V	− 7·6 a	−0·537	−1·210	1, 2, 3
4993	ι CMa	4·60	+1·23	...	K2 III	−15·4	0·000	−0·023	1+, 2, 3
5317	HR 3131	4·62	+0·08	+0·09	A3 V	−12·0 c	−0·008	−0·047	1, 2, 3
*5899	α Cnc	4·22	+0·18	...	Am	−13·8 b	+0·034	−0·035	1, 2, 3
5935	υ Cnc	5·46	−0·03	−0·10	Ap	−15·1 b	−0·002	−0·009	1, 2
*5947	α Vol	4·02	+0·15	...	Am	+ 4·9 b	+0·004	−0·102	1+, 2, 3
*6050	HR 3676	5·7	...	...	A1	−12·1 a	+0·019	+0·006	1, 2, 3
*6154	23 UMa	3·66	+0·33	+0·10	F0 IV	− 9·5 b	+0·109	+0·024	1, 2, 3
6404	21 LMi	4·48	+0·18	+0·08	A7 V	−17·8 b	+0·054	−0·001	1, 3
*6440	34 Leo	6·44	+0·46	+0·02	F6 V	−16·0 b	+0·037	−0·040	1, 6
6478	ζ Leo	3·44	+0·30	+0·20	F0 III	−15·0 b	+0·017	−0·013	1, 2, 3

TABLE I—*continued*

W	Name	V_E	$B-V$	$U-B$	Sp	ρ Q	μ_α	μ_δ	S
		m	m						
6614	37 UMa	5·16	+0·34	−0·01	F1 V	−12·3 a	+0·067	+0·034	1, 2, 3
*6705	μ Vel	2·67	+0·90	...	G5 III	+ 6·9 a	+0·072	−0·053	1, 2, 3
6809	β UMa	2·36	−0·02	+0·02	A0 V	−12·0 a	+0·083	+0·028	1, 2, 3
6812	61 Leo	4·73	+1·62	...	K5 III	−13·5 a	+0·015	−0·037	1, 3
6892	δ Leo	2·55	+0·13	+0·12	A4 V	−20·6 b	+0·144	−0·137	1, 2, 3
6985	τ Leo	4·95	+1·00	+0·80	G8 II	− 9·1 a	+0·017	−0·016	1, 2, 3
7119	ζ Crt	4·74	+0·96	+0·76	G5 III	− 4·6 a	+0·035	−0·038	1, 2, 3
7177	γ UMa	2·44	0·00	+0·01	A0 V	−12·9 a	+0·094	+0·005	1, 2, 3
7276	α Crv	4·03	+0·31	−0·02	F2 IV	+ 4·4 a	+0·083	−0·050	1+
...	HD 109011	8·09	+0·93	+0·64	K2 V	−12·4 b	+0·104	−0·004	7
7337	δ UMa	3·29	+0·09	+0·07	A3 V	−12·9 b	+0·104	+0·003	1, 2, 3
*7590	HR 4803	5·45	+0·33	+0·02	F2 V	− 0·9 a	+0·075	−0·097	1+
7630	HD 110463	8·27	+0·95	+0·76	K3 V	− 6·3 b	+0·130	−0·008	1, 4
7659	34 Vir	6·0	...	...	A3	− 3·0 c	+0·038	−0·023	1+
7675	29 Com	5·70	+0·01	+0·07	A2 V	− 7·0 b	+0·029	−0·031	1+, 3
7678	HR 4867	5·85	+0·46	−0·04	F6 V	−12·0 b	+0·110	−0·006	1, 4
7714	41 Vir	6·26	+0·27	+0·05	A7 p	−10·0 c	+0·054	−0·032	1+, 2
7722	ε UMa	1·76	−0·02	+0·03	Ap	− 9·3 a	+0·113	−0·011	1, 2, 3
*7762	78 UMa	4·93	+0·36	+0·01	F2 V	−10·4 b	+0·117	−0·014	1, 2
*7825	HD 114260	7·19	+0·73	(+1·82)	dG7	− 8·8 b	+0·113	−0·030	1, 4
*7958/9	ζ UMa	2·04	+0·02	+0·04	A2 V, Am	− 9·0 a	+0·122	−0·027	1, 2, 3
7966	80 UMa	4·01	+0·15	+0·08	A5 V	− 7·5 a	+0·120	−0·024	1, 4
8035	78 Vir	4·94	+0·04	0·00	Ap	− 8·0 a	+0·041	−0·030	1, 2
8177	HR 5214	6·65	+0·11	+0·07	A4 V	−12·3 b	+0·031	−0·017	1, 4
*8325	κ Boo B	6·69	+0·39	−0·04	F2 V	−15·6 a	+0·064	−0·013	1, 4
*8328	κ Boo A	4·54	+0·20	+0·14	A7 IV	−15·6 a	+0·064	−0·013	1, 4
8344	HR 5343	5·98	+0·26	+0·05	Am	0·0 c	+0·043	−0·040	1+
8383	HR 5373	6·33	+0·05	+0·05	A2 V	−10·5 b	+0·023	−0·018	1, 4
8531	HR 5473	6·0	...	...	A8	− 7·9 b	+0·052	−0·030	1+
*8537	ζ Boo	3·78	+0·04	+0·05	A2 III	− 4·6 b	+0·050	−0·026	1, 5
*8553	HR 5492	6·25	+0·41	−0·01	F2 III	− 6·3 b	+0·070	−0·037	1, 4
8747	45 Boo	4·92	+0·44	−0·03	F5 V	− 7·3 b	+0·182	−0·173	1, 2, 3
*8909	η Cr B	4·98	+0·58	+0·04	G2 V	− 6·8 a	+0·134	−0·192	1, 5
*8990	α Cr B	2·23	−0·02	−0·02	A0 V	+ 1·7 a	+0·118	−0·094	1, 2, 3
9054	19 Ser	6·01	+0·90	+0·61	G5 III	+ 3·4 a	+0·023	−0·020	1+
*9094	β Ser A	3·67	+0·06	+0·07	A2 IV	− 0·8 b	+0·066	−0·049	1, 2, 3
*9095	β Ser B	9·95	+0·99	+0·81	dK3	− 0·8 b	+0·066	−0·049	1, 2, 3
...	β Ser CD	8·07	+0·66	...	G0	− 0·8 b	+0·066	−0·049	1, 2, 3
*9376	ν Cr B	5·78	+0·07	+0·10	A3 III	+ 2·0 c	+0·016	−0·024	1, 3
*9448	ζ Tr A	4·86	+0·54	...	dG0	+ 8·5 a	+0·205	+0·102	1, 2, 3
*9677	52 Her	4·80	+0·09	+0·04	Ap	0·0 a	+0·022	−0·063	1, 4
*9747	56 Her	6·08	+0·92	+0·62	G5 III	+ 1·1 a	+0·011	−0·026	1
10058	HR 6481	5·69	+0·06	+0·10	A3 III	+11·2 b	+0·010	−0·035	1+
*10916	HR 6917	5·83	+0·05	+0·09	A2 V	+ 8·5 a	+0·015	−0·024	1, 2, 3
*11082	HR 6993	5·75	+0·08	+0·06	A2	+12·4 a	+0·009	−0·024	1, 3
*11218	5 Aql AB	5·66	+0·17	+0·08	Am	+17·0 c	+0·009	−0·024	1+
*11426	10 Aql	5·90	+0·26	...	Ap	+14·5 a	−0·005	−0·050	1, 2
11674	59 Dra	5·12	+0·30	−0·01	F2 V	− 4·0 a	+0·044	−0·122	1, 3
11855	HR 7382	5·9	...	...	gG5	− 0·1 b	+0·012	−0·030	1, 4
11988	HR 7451	5·72	+0·47	−0·01	F8 V	+ 1·2 b	+0·026	−0·193	1, 4
*12789	ρ Cap	4·77	+0·35	...	F2 III	+18·4 b	−0·016	−0·023	1, 2, 3
12981	β Pav	3·44	+0·14	+0·05	A5 IV	+ 9·8 b	−0·039	+0·016	1, 2, 3
*12987	δ Del	4·5	+0·34	...	F2 III	+ 9·3 a	−0·024	−0·044	1, 2, 3
*13628	76 Cyg	6·10	+0·06	+0·06	A2	+ 3·0 d	−0·014	−0·047	1, 4
*13854	HR 8407 AB	5·60	−0·40	−0·10	A0	− 1·2 b	−0·018	−0·032	1, 4
*13866	32 Aqr	5·32	+0·22	+0·14	g A8	+20·4 a	−0·021	−0·044	1, 2
13931	π Peg	4·30	+0·45	+0·18	F5 II-III	+ 2·0 b	−0·017	−0·020	1, 2, 3
*14359	γ Ps A	4·42	−0·02	...	A0 V	+16·5 b	−0·035	−0·024	1, 2
...	HD 217595	7·22	+0·43	...	F5 V	+20·5 b	−0·018	−0·008	1+

**Notes to* TABLE I

No.	
1019	The $U-B$ was determined with the Cape refractor and shows an excess of $\delta(U-B)_C = +0^{m}{\cdot}02$ (Eggen 1959a).
1106	ADS 1598, see Section 4.
1222	ADS 1709, see Section 4.
1463	ADS 1971, 9^{m} 8″.
2546	The discordant velocity determination from Yerkes Observatory has been omitted.
2566/7	ADS 4334.

**Notes to* TABLE I—*continued*

3730 Spectroscopic and eclipsing binary, luminosity corrected for equal components before plotting in Fig. 1; see Section 5.
4050 Sp. B., $P=870^d$.
4079 Spectroscopic and eclipsing binary; see Section 5.
4392 ADS 5423; see Section 4.
5899 ADS 7115, 11^m 11″.
5947 Sp. B with double lines; luminosity corrected for equal components before plotting in Fig. 1.
6050 Sp. B., $P=16^d$.
6154 ADS 7402, 9^m 23″.
6440 ADS 7674, $\Delta m=0^m{\cdot}5$. There are few observations of this pair, which was discovered in 1905 ($\theta=290°$, separation$=0''{\cdot}22$) and was too close in 1949–51 for van Biesbroeck to separate with the 82-inch reflector.
6705 Visual binary, 7^m 2″.
7590 ADS 8612, 12^m 2″.
7762 ADS 8739, see Section 4.
7825 $\delta(U-B)c=+0^m{\cdot}02$ (Eggen 1959a).
7958/9 ADS 8891, $\Delta m=1^m{\cdot}66$; the bright component is also an interferometric double; see Section 4.
8325/8 ADS 9713; the fainter component is Sp. B, no period.
8537 ADS 9343, $\Delta m=0^m{\cdot}02$, luminosity corrected for equal components before plotting in Fig. 1; see Section 4.
8553 ADS 9357, $\Delta m\approx 1^m{\cdot}5$.
8909 ADS 9617, $\Delta m=0^m{\cdot}26$; luminosity corrected for equal components before plotting in Fig. 1; see Section 4.
8990 Spectroscopic and eclipsing binary; see Section 5.
9094/5 ADS 9778; CD is ADS 9766.
9376 ADS 9990, 3 companions all fainter than 10^m.
9448 Sp. B., $P=13^d$.
9677 ADS 10227, 10^m $1''{\cdot}5$; the companion is itself double, see Section 4.
9747 ADS 10259, 10^m 18″.
10916 Sp. B., $P=10^d$.
11082 Sp. B., $P=?$
11218 ADS 11667, Δm (AB)$=1^m{\cdot}59$, C is 11^m 27″.
11426 Although shown as filled circle in Fig. 1 (metallic-line), this star is actually a " peculiar " star with the latest known A-type.
12989 ADS 13887, 10^m 2″.
12987 δ Scuti-type variable (Eggen 1956).
13628 Sp. B. with range of 43 km/sec, no period.
13854 ADS 15578, $\Delta m\approx 2^m$, separation of $0''{\cdot}5$, little observed.
13866 Sp. B., $P=8^d$.
14359 Visual binary, 8^m 4″.

TABLE II

Parallaxes, luminosities and space motions of stars in Table I

No.	π_g (0″·001)	M_V	U	V	W	No.	π_g (0″·001)	M_V	U	V	W
		m	km/sec					m	km/sec		
164	28	+1·77	−15	−3	−1	4392	375	+1·41	−14	0	−11
228	7	0·0:	−14	−2	0	4993	16	+0·62	−15	+1	−7
378	9	−0·65	−13	+2	−16	5317	14	+0·35	−16	+2	−12
408	10	+0·5	−14	0	+3	5899	33	+1·81	−14	+2	−6
1019	50	+5·28	−15	0	−4	5935	10	+0·46	−11	+1	−11
1021	56	+3·36	−14	+2	−5	5947	27	+1·18	−14	0	−12
1106	25	+1·49	−12	+3	−3	6050	13	+1·3	−13	+1	−7
1222	22·5	+2·72	−14	−1	−14	6154	49	+2·11	−14	−1	0
1463	8	−0·62	−13	+4	−18	6404	50	+2·98	−14	+2	−12
1616	12·5	+0·26	−14	+2	−3	6440	26	+3·51	−15	+2	−11
2197	19	+0·50	−14	+1	−10	6478	12	−1·16	−14	+1	−10
2546	23	+1·98	−14	0	−9	6614	40	+3·17	−13	+2	−7
2871	15	+0·65	−17	0	−7	6705	30	+0·06	−14	0	−10
3046	30	+0·19	−14	+1	−16	6809	42	+0·48	−13	+2	−7
3566	130	+6·72	−15	+4	−12	5812	12·5	+0·22	−13	−1	−15
3567	130	+4·17	−15	+4	−12	6892	90	+2·32	−15	+2	−17
3663	(101)	+4·43	−13	+3	−9	6985	8	−0·53	−14	+2	−9
3730	23	−1·29	−16	+1	−14	7119	16	+0·76	−14	+1	−8
3836	70	+5·96	−12	0	−12	7177	42	+0·56	−13	+1	−10
4050	17	−0·04	−14	0	−11	7276	33	+1·62	−14	+3	−8
4079	18	+1·92	−13	0	−8	HD 10911	40	+6·10	−14	+1	−9

TABLE II—*continued*

No.	π_g (0″·001)	M_V	U	V (km/sec)	W
		m			
7337	44	+1·51	−14	0	− 9
7590	30	+2·84	−14	−1	−12
7630	50	+6·77	−12	+3	− 5
7659	14	+1·7	−14	+1	− 5
7675	13	+1·27	−14	−2	−10
7678	43	+4·02	−14	0	−10
7714	19·5	+2·70	−14	+4	−13
7722	44	−0·02	−13	+2	− 8
7762	45	+3·20	−14	+1	− 9
7825	46	+5·50	−14	+4	−18
7875	42	+4·96	−14	+1	− 7
7958/9	42	+0·16	−14	+2	− 8
7966	43	+2·18	−13	+3	− 7
8035	13·5	+0·59	−13	+4	−15
8177	11	+1·86	−14	0	−14
8325	19	+3·08	−14	+1	−17
8328	19	+0·91	−14	+1	−17
8344	18	+2·26	−14	−1	− 6
8383	8·5	+0·98	−14	−2	−13
8531	13	+1·6	−14	+4	−18
8537	14·5	−0·42	−13	+4	−13
8553	28·5	+3·53	−13	+1	− 7
8747	61	+3·85	−14	+2	−15
8909	65	+4·04	−13	−4	−12
8990	45	+0·50	−14	+2	− 7

No.	π (0″·001)	M_V	U	V (km/sec)	W
		m			
9054	9·5	+0·89	−14	+2	− 8
9094	23	+0·48	−14	+2	−14
9095	23	+6·76	−14	+2	−14
β Ser CD	23	+4·88	−14	+2	−14
9376	9	+0·55	−14	−1	− 6
9448	95	+4·75	−12	+2	− 7
9677	21	+1·41	−14	−2	− 4
9747	8·5	+0·73	−13	−4	− 8
10058	18	+1·92	−15	+2	0
10916	7·5	+0·21	−15	+4	−11
11082	12	+1·15	−14	+1	− 7
11218	15	+1·54	−18	+2	− 4
11426	20	+2·41	−17	+2	− 4
11674	40	+3·13	−12	+4	−10
11855	8	+0·4	−14	0	−14
11988	53	+4·34	−15	+2	−10
12789	25	+1·76	−17	+2	− 8
12987	19	+0·9	−14	0	− 4
13628	13·5	+1·75	−14	+1	−10
13854	11·5	+0·90	−14	−2	− 5
13866	15	+1·20	−18	+4	−17
13931	9·5	−0·82	−14	0	−14
14359	26	+1·49	−14	+2	−16
HD 217595	22	+3·83	−12	−3	−16

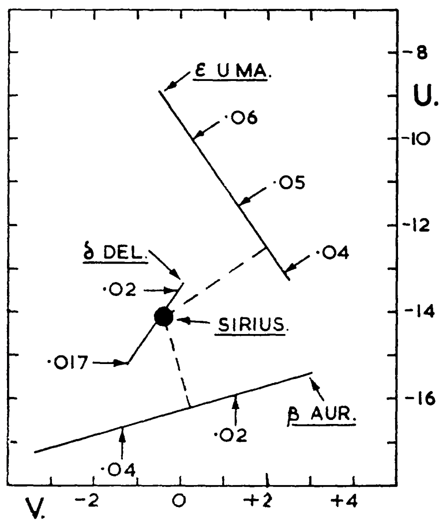

FIG. 1.—*A section of the* (*U, V*)*-plane containing Sirius* (*filled circle*) *at* (*U, V*)=(−14·2, −0·4). *Points corresponding to various values of the parallax for three probable members of the group, β Aur, δ Del and ε UMa, are indicated on the* (*U, V*)*-loci of these stars. The parallax corresponding to the shortest distance between* (*U, V*)=(−14·2, −0·4) *and the* (*U, V*)*-locus, indicated by the dashed line, is taken to be the group parallax.*

This list of members is not only very incomplete, even for the stars with known proper motion and radial velocity, but also it undoubtedly contains several spurious members. All stars brighter than visual magnitude 5·5 have been included on radial velocity and proper motion programmes and the completeness of Table I to this limit is affected only by the errors of observation. However, very few fainter stars more distant than about 50 parsecs will be included because of the small total space velocity of the group, V_t= 18·4 km/sec (Sirius), with respect to the Sun. The parallax of a group member is related to the proper motion by the expression $\mu \approx 4\pi \sin\lambda$, where λ is the angular distance of the star from the apparent convergent point of the group motion. Even in the most favourable case, when $\sin\lambda = 1$, a group member more distant than 50 parsecs will have $\mu < 0''\cdot 1$ and relatively few stars with such small motions have been included on radial velocity programmes.

It is obvious that the group parallax of stars near (or 180° from) the convergent point is nearly indeterminate because the space motion is then almost completely in the radial direction. However, it should also be noted that the present procedure causes the same situation to arise in the special cases where the proper motion is mainly reflected in the W-motion. For example, the dependence of (U, V, W) for χ' Ori (W 3663) on π_g is as follows:

π_g	U	V	W	
0″·100	−13·1	+3·0	−9·4	km/sec
0″·200	−12·5	+3·6	−3·9	km/sec

The group parallax in this case is nearly indeterminate and the well-determined trigonometric parallax is given in parentheses in Table II.

The difficulty in assigning individual stars to membership in the Sirius group on the basis of a motion criterion alone can be emphasized in the following way.

(i) A catalogue has been compiled of 400 stars brighter than visual magnitude 5 and (*a*) with spectral types between B5 and F6, (*b*) of luminosity class III, IV, or V—the two-dimensional Mt Wilson system has been used for a few stars—and (*c*) with reliable radial velocities.

(ii) The (U, V)-locus for each star has been computed from the assumption that the luminosity is within $\pm 0^{\mathrm{m}}\cdot 5$ of that given by the calibration of the luminosity classes (Keenan and Morgan, cf. Hynek 1951).

(iii) The (U, V)-values for the AV, Ap and Am stars were shown in Paper VI (Fig. 2) to lie in a very restricted region of the (U, V)-plane with few stars other than those in the Sirius group having negative values of both U and V—that is, that are following the Sun in their motion in the direction of galactic rotation.

(iv) The (U, V)-loci for those stars of the 400 mentioned above, which follow the Sun in the direction of galactic rotation, are shown in Fig. 2. These include:

(*a*) The AV, Ap and Am stars (solid lines) most of which were included in the previous discussion (Paper VI, Fig. 2).

(*b*) The luminosity class III and IV stars (broken lines).

(*c*) The stars assigned to the Sirius group in Table I are indicated by crosses at the (U, V)-values given in Table II. The large circle is centred on the (U, V)-value for Sirius and has a radius of 4 km/sec. From the distribution of the crosses it appears that (*a*) too large a tolerance has been placed on the V-motions, (*b*) there is a larger dispersion in the V- than in the U-motions of group members, or (*c*) the procedure of taking the group parallax as that value which corresponds to the point on the (U, V)-locus closest to $(U, V) = (-14\cdot 2, -0\cdot 4)$ is incorrect. The latter possibility arises because the majority of the (U, V)-loci for these stars lie more nearly parallel to the U-axis than to the V-axis so that adopting the minimum length of the normal to the loci passing through $(U, V) = (-14\cdot 2, -0\cdot 4)$ tends to minimize the dispersion of the U-motions.

It is interesting to note that only one or two stars with spectral type between B5 and A0 have negative values of both U and V.

(v) The possibility of including spurious members in the Sirius group is obvious in Fig. 2. All stars whose (U, V)-loci cut the circle around the (U, V)-value for Sirius are candidates for membership if the motion criterion alone is used. On the other hand, any estimate of the luminosity that is accurate to, say, one magnitude in most cases restricts the (U, V)-locus to a very limited region of the (U, V)-plane and permits the star to be assigned to a definite group with some accuracy.

(vi) The Sirius and Hyades (Paper VII) groups both lie near the edge of the (U, V)-distribution for a pure sample of older Population I—that is, the AV, Ap and Am stars—and, therefore, the members of these groups are the easiest to isolate in that population. However, when older stars, represented by the broken lines in Fig. 2, are included this advantage is no longer held by the two groups but is transferred, for the stars in Fig. 2, to the group with $(U, V) = (-25, -3)$. This group, which we will call the α Ophiuchi group, will be discussed in detail in a later paper. Moreover, when a selection of stars that contains still older objects is considered—such as spectral types later than F5 (Paper III) or subgiants (Paper V)—the (U, V)-dispersion becomes even larger and such high velocity groups as the ζ Herculis, 61 Cygni and γ Leonis groups become the easiest to isolate. For the same reason it is obvious that the probability of including spurious members in, say, the Sirius group is greater for stars of type later than about F5 than it is for main sequence A-type stars.

(vii) It should be noted that the (U, V)-loci shown in Fig. 2 assume that there is no error in the observed radial velocities or proper motions. Uncertainties in the observed components of the motions will broaden the loci but the broadening due to errors in the proper motion will be dependent upon the parallax and will give fan-shaped loci with increasing width for decreasing parallax.

(viii) There are at least three other groups in addition to the Sirius group in Fig. 2. Five of the stars may share the motion of Procyon, which is indicated by the crossed circle. The apparent group near $(U, V) = (-8, +5)$ is that numbered 7 in Paper VI. The values of $(U, V) = (-25, -3)$ for the α Ophiuchi group were determined by treating the loci as "Sumner-lines" and obtaining a "fix" by minimizing the sum of the squares of the lengths of the normals to the loci.

2. *The* $(M_V, B-V)$-*diagram.*—The colours and luminosities of the stars in Tables I and II are displayed in Fig. 3 where the main sequence defined by the Hyades cluster stars (Sandage and Eggen 1959) is also shown. This diagram is more open that that previously found (Paper I), mainly because of the inclusion of many stars as group members by the procedure used here that were excluded by the convergent point method. The most noteworthy features of Fig. 3 are the following:

A. The most obvious feature of the $(M_V, B-V)$-diagram for the Sirius group members is the apparent displacement of the main sequence from that of the Hyades cluster stars. If we omit known binaries (crosses) and the one star slightly above the main sequence at $B-V = +0^{m}\cdot92$, an eighth magnitude object for which only a photographic proper motion is available, the average displacement of the stars redder than $B-V = +0^{m}\cdot4$ is M_V (Sirius group) $- M_V$

(Hyades group) = $+0^{m}\cdot2$. This displacement is also reflected in the $(U-B, B-V)$-relation for the Sirius group stars, compared with those in the Hyades group, shown in Fig. 4. Here the "standard" relation, derived from the Hyades cluster members, is shown as a continuous curve; the extension for $B-V < +0^{m}\cdot35$, as indicated by the main sequence Hyades group members (Paper VII), is shown as a dotted curve. The main sequence, or near main sequence, members of the Sirius group are indicated by open circles, the metallic-line and peculiar A-type stars by crosses, and the G- and K-type giants by filled circles; the two stars indicated by open boxes will be discussed below.

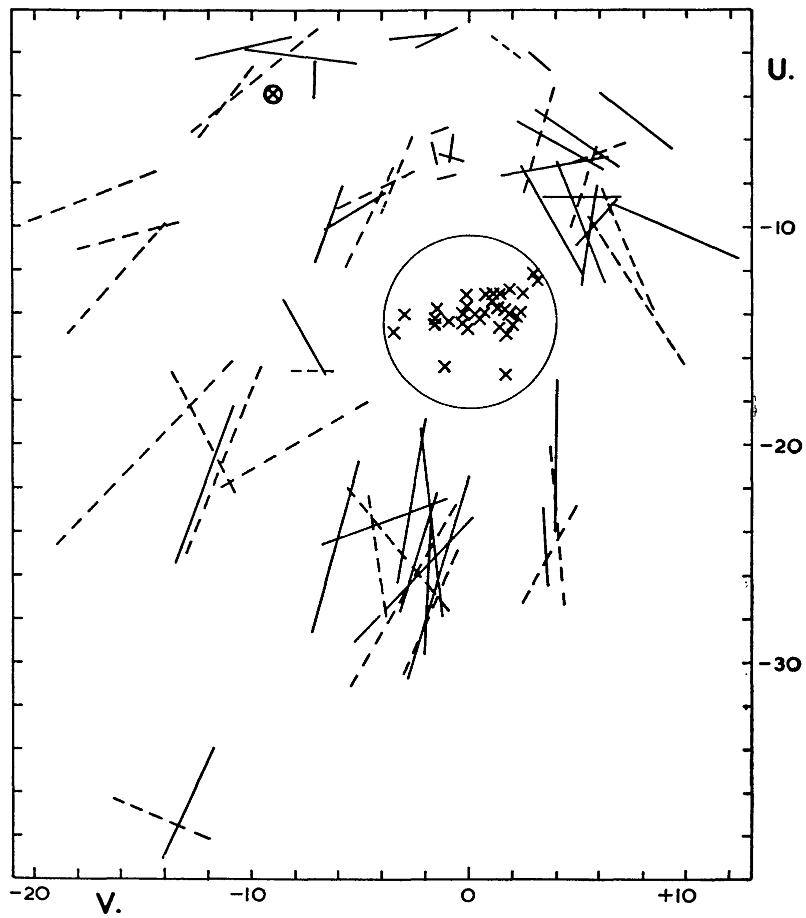

FIG. 2.—*The* (*U, V*)*-loci for AV, Ap, and Am stars* (*continuous lines*) *and B8 to F5 stars of luminosity class III or IV* (*broken lines*) *brighter than visual magnitude* 5·0. *The crosses represent members of the Sirius group and the large circle is centred on the* (*U, V*)*-value for Sirius and has a radius of* 4 *km/sec. The crossed circle represents the accurately known position of Procyon.*

The main sequence stars bluer than $B-V = +0^{m}\cdot2$ appear to have the same $(U-B, B-V)$-relation as the Hyades stars in the colour range common to both groups. However, the Sirius group members with $+0^{m}\cdot3 \leqslant B-V \leqslant +0^{m}\cdot6$ definitely depart from the standard relation and show an average ultra-violet excess, $\delta(U-B)$, of $+0^{m}\cdot04$. If this excess is interpreted as due to line-blanketing (Sandage and Eggen 1959, Table IV) the expected ΔM_V (Sirius–Hyades) is $+0^{m}\cdot3$; the agreement with the observed value is excellent in view of the preliminary nature of the blanketing theory. In testing the theory with known subdwarfs near the Sun, Sandage and Eggen found that $\delta(U-B)\approx 0$ for subdwarfs redder than $B-V\approx +0^{m}\cdot 8$. This same result is obtained for the red dwarfs in the Sirius group and indicates that the "blanketing line" in the $(U-B, B-V)$-diagram lies along the intrinsic $(U-B, B-V)$-relation for these stars. Unfortunately, values of $(U-B)$ are not available for the few known dwarfs in the Sirius group with $+0^{m}\cdot 6 < B-V < +0^{m}\cdot 8$. Two stars in this interval, W 1019 and W 7825, have values of $B-V=+0^{m}\cdot 63$ and $+0^{m}\cdot 73$, respectively, and the ultra-violet colours, $(U-B)_C$, obtained with the Cape refractors give $\delta(U-B)_C=+0^{m}\cdot 02$ for both. Adopting the rough relation (Eggen 1959 a), $\delta(U-B)=1\cdot 5\,\delta(U-B)_C$, the resulting values of $\delta(U-B)$ are in good agreement with those found above for the bluer main sequence objects. The ultra-violet excesses for some of the Sirius group members (cf. χ^1 Ori, Eggen 1959 a) are also shown by the 6-colour photometry of Stebbins and Whitford (1945) and Stebbins and Kron (1956).

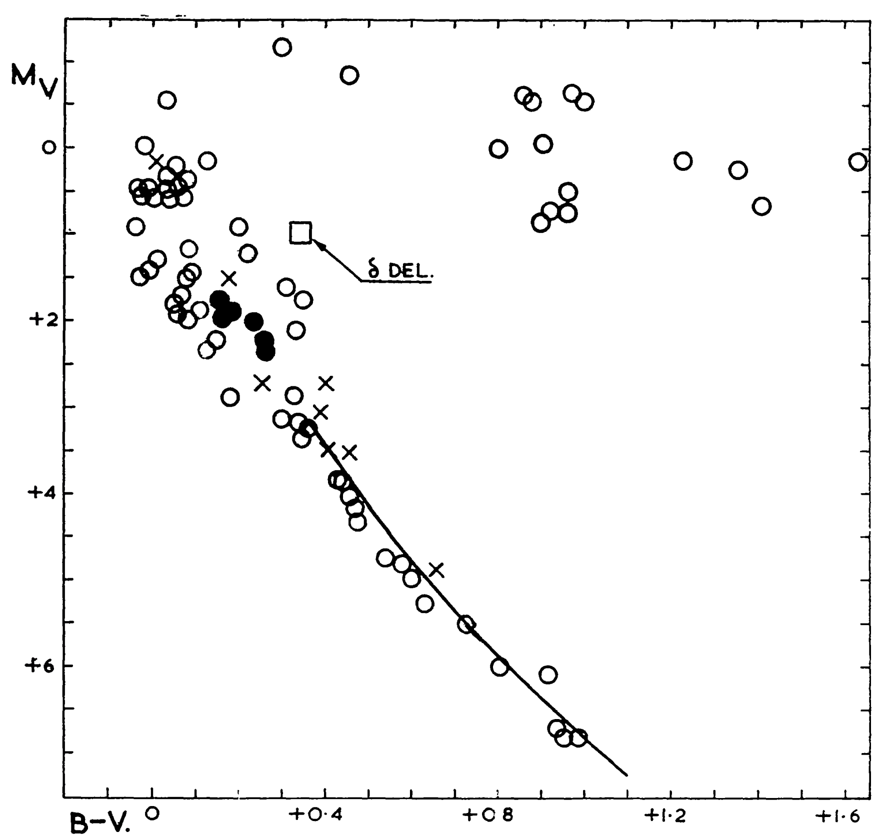

FIG. 3.—*The $(M_V, B-V)$-diagram for the Sirius group members. The continuous curve represents the main sequence of the Hyades cluster stars, the crosses represent known binaries with companions bright enough to affect materially the observed colour and magnitude, and the filled circles represent metallic-line stars. The δ Scuti-type variable, δ Del, is shown as an open box.*

B. The metallic-line stars in the group (filled circles), like those in galactic clusters (Eggen 1957, 1959 b) populate a restricted region of the $(M_V, B-V)$-diagram on the red side of the A-type main sequence stars. Wilson No. 11426 (10 Aql), although classified as A4p and "of a later A type than most of the magnetic stars" (Babcock 1958), falls among the metallic-line stars in Fig. 3

and is represented there by a filled circle. The wide binary W 7958/9 (ζ UMa) consists of a main sequence A-type star, which is itself a binary (Section 4), and a fainter, metallic-line star; the observed luminosity and colour of the system are indicated in Fig. 3 by a cross at $M_V = +0^m{\cdot}16$ and $B-V = +0^m{\cdot}02$. Since the visual magnitude difference in the wide pair is $1^m{\cdot}66$, the metallic-line component falls in the centre of the region populated by the metallic-line stars at $M_V = +2^m{\cdot}03$. The colour of this component is, therefore, probably near $B-V = +0^m{\cdot}20$, leaving $B-V \approx 0^m{\cdot}0$ and $M_V = +1^m{\cdot}12$ for the equal components of the bright star. If evolution of A-type main sequence stars is accompanied by increasing colour, then we are led to the conclusion that ζ UMa B ($M_V = +2^m$) is in a more advanced stage of evolution than the two intrinsically brighter stars ($M_V = +1^m$) that form ζ UMa A.

It seems reasonable to interpret the metallic-line stars as representing a definite stage in the evolution of A-type main sequence dwarfs but whether they have evolved from main sequence objects of the same or of lower luminosity may only be settled with a knowledge of the stellar masses.

C. The small amplitude, short period light and velocity variable δ Del (Eggen 1957) has a luminosity very similar to that found for the prototype variable δ Scu (Paper VII). The five stars lying between δ Del and the region of the metallic-line stars are, in order of decreasing luminosity: κ Boo A (F2 IV), 32 Aqr (gA8), α Crv (F2 IV), ρ Cap (F2 III), and 23 UMa (F0 IV). The observed line-widths of three of these stars (κ Boo A, ρ Cap, and 23 UMa) indicate values of $V_r \sin i$ between 115 and 150 km/sec (Slettebak 1954, Herbig and Spalding 1955) while those for two of the metallic-line stars give $V_r \sin i \approx 70$ km/sec; the value for δ Del is 35 km/sec. The available determinations of $V_r \sin i$ for the group members are shown on a $(M_V, B-V)$-diagram in Fig. 5; the few values available for late-type giant members are all <25 km/sec. The axes of rotation may be randomly distributed or there is no close correlation between main sequence luminosity and rotational velocity and Fig. 5 gives no obvious clue to the main sequence origins of δ Del or any of the non-main sequence stars in the figure.

D. The dense clumping of A-type stars near $M_V = +0^m{\cdot}5$ contains such diverse objects as the peculiar stars α Cnc and 78 Vir, the eclipsing variable α CrB and several A0–A3 stars of luminosity class V. Although the group membership represented by the objects in Table I is obviously incomplete, it does not seem likely that this fact alone can explain such a relatively heavy concentration of stars with a sharp cut-off near $M_V = +0^m{\cdot}6$ at the edge of an $\sim 0^m{\cdot}5$ gap in the main sequence.

E. The two stars represented in Fig. 4 by open boxes are ζ Leo ($M_V = -1^m{\cdot}2$, $B-V = +0^m{\cdot}30$) and π Peg ($M_V = -0^m{\cdot}8$, $B-V = +0^m{\cdot}45$). The large ultraviolet deficiencies for these stars may be connected with the fact that at least one of them, π Peg, is known to be a shell star (Greenstein 1953).

F. The distribution in the $(M_V, B-V)$-diagram of the G- and K-type giant members of the Sirius group differs markedly from the orderly sequence from $B-V = +0^m{\cdot}95$, $M_V = +1^m$ to $B-V = +1^m{\cdot}6$, $M_V = -0^m{\cdot}5$ found for the Hyades giants (Paper VII). Although this difference may be partially caused by the inclusion of spurious members in the Sirius group, especially in the case of the small proper motion stars redder than $B-V = +1^m{\cdot}2$, there is undoubtedly a real difference in the spread of luminosity for the G-type giant members in the

43*

two groups. This difference is also reflected in the colour–spectral type relation for the giants in the two groups since those with colour near $+0^{m}{\cdot}95$ are classified K0 III in the Hyades and G5 III in the Sirius group. Group membership of individual giant stars in the Sirius group can ultimately be tested through independent luminosity determinations such as those of Wilson and Bappu (1957).

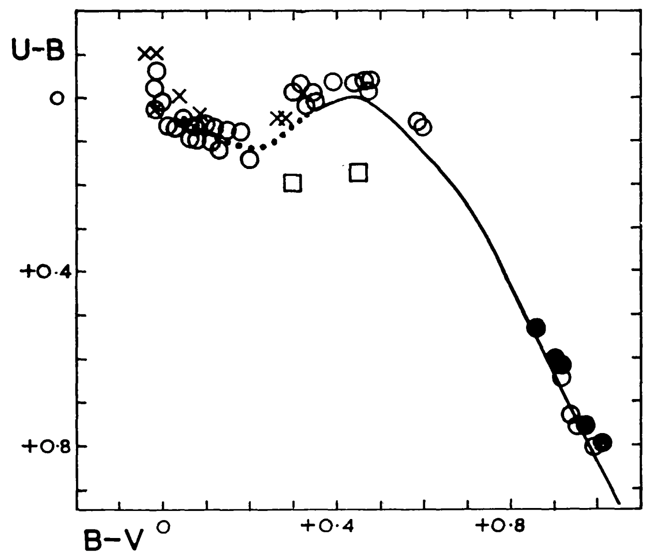

FIG. 4.—*The (U−B, B−V)-relation for group stars not known to be binaries. The standard relation, for the Hyades cluster stars, is shown as a continuous curve with an extension indicated by the Hyades group stars shown as a dotted curve. Metallic-line and peculiar A-type stars are shown as crosses, G- and K-type giants as filled circles, and the bright F-type giants, ζ Leo and π Peg, as open boxes.*

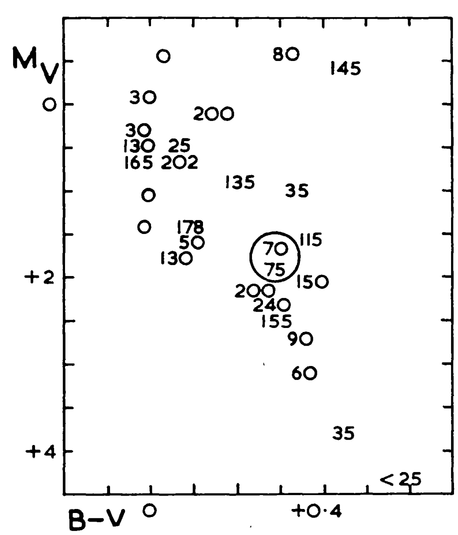

FIG. 5.—*Available estimates of $V_r \sin i$, in km/sec, for group stars marked on a (M_V, B−V)-diagram. The values for two metallic-line stars are circled.*

G. A comparison between the schematic (M_V, $B-V$)-diagrams for the Hyades (hatched) and Sirius (unhatched) groups is shown in Fig. 6. The few Hyades (crosses) and Sirius (open circles) group members falling outside the enclosed areas are also indicated in the figure. Although the effects of evolution on the main sequence stars are apparent to about the same luminosity in both groups ($M_V \approx +3^m$) the presence of bluer main sequence stars and brighter G-type giants in the Sirius group indicates that, on the basis of the evolutionary theory (Sandage 1958), this is the younger group.

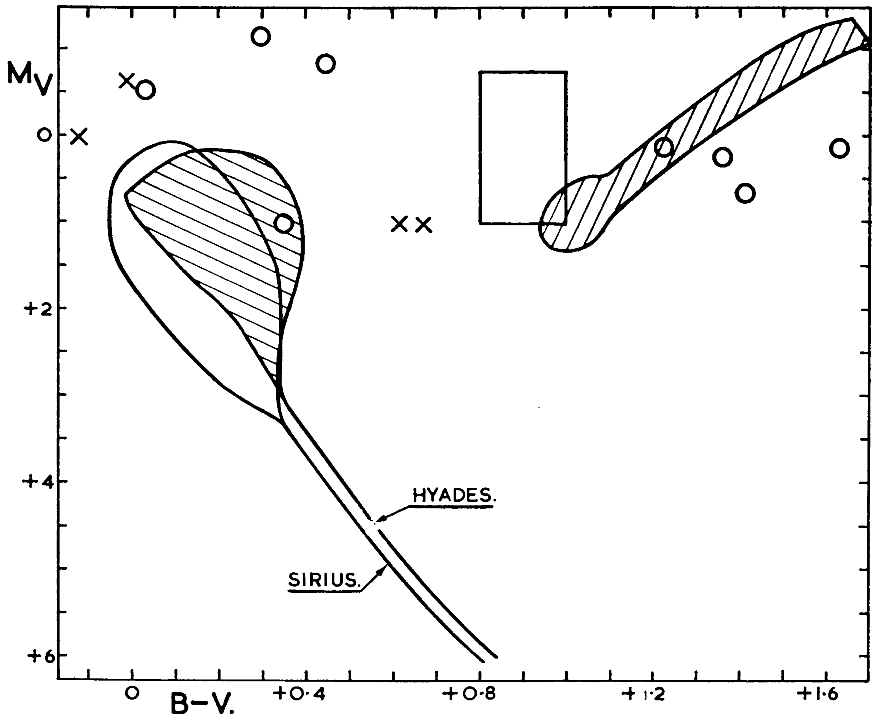

FIG. 6.—*A comparison of the schematic* (M_V, $B-V$)*-diagrams for the Hyades* (*hatched*) *and Sirius* (*unhatched*) *groups. A few Hyades* (*crosses*) *and Sirius* (*open circles*) *group stars falling outside the enclosed areas are also shown.*

H. The large number of blue stars brighter than $M_V = +2^m$ compared to the relatively small number populating the lower main sequence indicates that, for any assumed luminosity function based on known galactic clusters, we can predict a very large number of undiscovered main sequence Sirius group members of G-type and later. In this connection the following M-type dwarfs are possible group members selected from Vyssotsky's (cf. 1956) spectrophotometric survey; the radial velocities of these stars are based almost entirely on one spectrogram for each star by Dyer (1954) and the proper motions are all uncertain:

BD/AC	vis. mag.	Sp	ρ km/sec	μ_α	μ_δ	π_g
				"	"	"
+16°2708	10·5	dM0	+ 5	+0·30	−0·14	+0·11
+22°2302	9·5	dM2	−20	+0·15	−0·04	+0·08
+22°214−219	9·5	dM0	− 7	−0·10	−0·21	+0·05
+23°2124	9·8	dK8	+ 3	−0·08	−0·10	+0·04
+30°1367	9·5	dM0	− 5	+0·09	−0·22	+0·08
+36°2393	9·6	dM2	+ 6	+0·30	−0·06	+0·11
+39°2675	9·2	dK8	− 8	+0·10	−0·10	+0·04
+55°1519	10·0	dM2	−10	+0·25	+0·08	+0·08
+63°965	9·1	dM0	− 6	+0·08	+0·01	+0·05

The spectra of all these stars show H and K lines in emission and the first three show emission lines of hydrogen.

The comparison between the group parallaxes and the trigonometric determinations is shown in Fig. 7. The trigonometric values are from the Allegheny (filled circles), McCormick (open circles), Cape (plus signs), Yale (crosses)

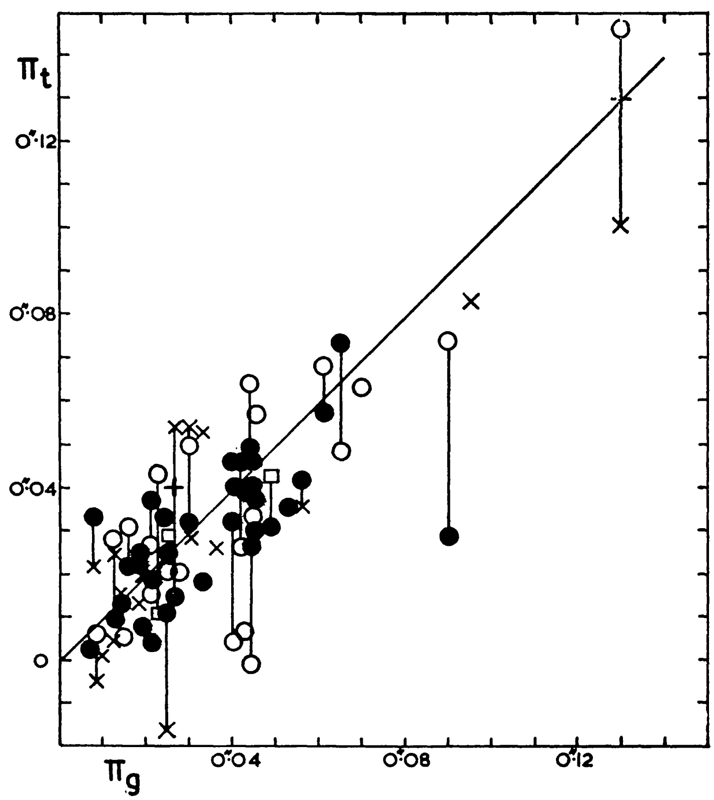

FIG. 7.—*The correlation between the group and trigonometric parallaxes. The observatories represented are Allegheny (filled circles), McCormick (open circles), Yale (crosses), Cape (plus signs) and Greenwich (boxes). Determinaticns by more than one observatory for the same star are connected by straight lines. The one-to-one correlation is represented by the 45° line. The large deviation for the Allegheny determination at $\pi_g = 0''\cdot090$ is for δ Lec.*

and Greenwich (boxes) Observatories; values by more than one observatory for the same star are connected by a straight line. The large deviation of the Allegheny determination at $\pi_g = 0''\cdot09$ is for δ Leo.

3. *Spatial distribution of group members.*—The spatial distribution of the stars in Table I is shown in Figs. 8 and 9. The stars within 25 parsecs (crosses) and between 25 and 50 parsecs (circles) of the galactic plane (including the Sun) are shown in Fig. 8, whereas those more than 50 parsecs above (filled circles) and below (open circles) the plane are shown in Fig. 9. Although, like the Hyades group (Paper VII), the distribution shown in Fig. 8 indicates that the Sirius group may be elongated roughly in the direction of galactic rotation, this result depends on only a few distant stars, and, because of the smallness of the proper motions and the resulting incompleteness in the known membership of the group, no conclusion on this point can yet be reached. Seventy-five per cent of the stars, including all but one of those represented by the clump of crosses near the Sun (X, Y = 0, 0) in Fig. 8, are above the galactic plane.

4. *Visual binaries.*—Eight visual binaries, including the interferometric pair ζ UMa Aa, among members of the Sirius group have known orbits. The orbital periods and semi-major axes adjusted to the "standard observers" (Eggen 1956), and group parallaxes of these systems are listed in Table III together with the resulting values of the mass and luminosity. Astrometric determinations of the mass-ratio have been used in determining the individual masses in three systems, but the magnitude difference between the components of the other four is small enough to permit the discussion of a mean component; the white dwarf companion of Sirius is not discussed here. The apparent magnitude of ADS 10227BC may be uncertain by $\sim 0^{m}.5$.

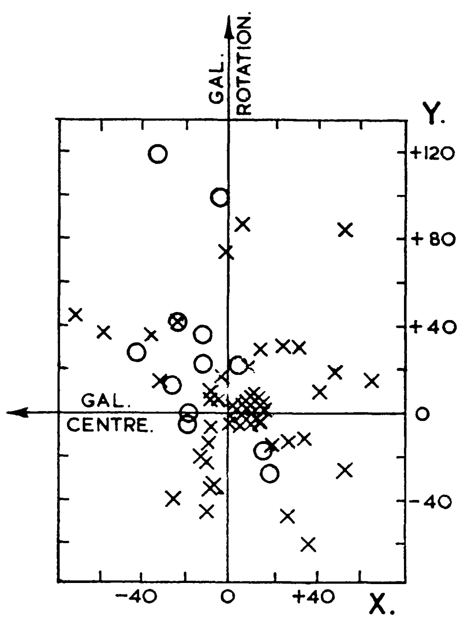

FIG. 8.—*The space distribution of the group members. Stars within 25 parsecs of the galactic plane (through the Sun) are shown as crosses and those between 25 and 50 parsecs of this plane by open circles. The Sun is at (X, Y)=(0, 0).*

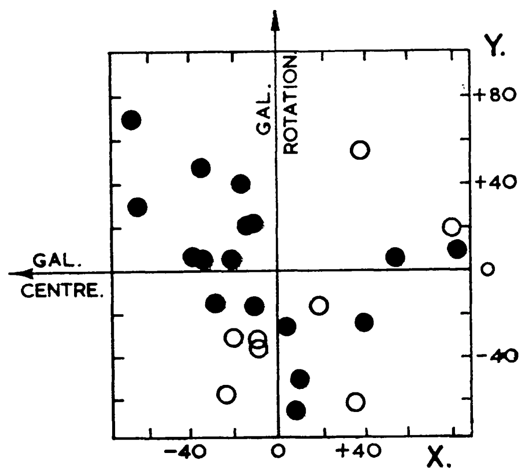

FIG. 9.—*Space distribution of stars more than 50 parsecs above (filled circles) and below (open circles) the galactic plane.*

TABLE III

Visual binaries with known orbital elements in the Sirius group

ADS	Wilson	Name	P (years)	a	π_g (0."001)	M_V	Mass (☉=1)
1598A	1106	48 Cas	60	0."680	25	+1·7	3·0
B						+3·4	2·6
1709AB	1222	—	144·7	0·91	22·5	+3·6	1·5
5423A	4392	α CMa	50·0	7·765	375	+1·4	2·5
8739A	7762	78 UMa	115·7	1·286	45	+3·3	1·2
B						+5·7	0·6
8891Aa	7958	ζ UMa	0·056	0·0115	42	+1·1	3·1
9343AB	8537	ζ Boo	126	0·60	14·5	+0·3	2·2
9617AB	8909	η CrB	41·6	0·888	65	+4·8	0·75
10227BC	9677	52 Her	51	0·29	21	+6·1	0·5

The masses and visual luminosities in Table III are plotted in Fig. 10; the visual luminosities are used here to avoid the difficulty with bolometric corrections. The mass–(visual) luminosity relation taken from a previous discussion (Eggen 1956), and here called the "normal relation", is shown in the figure as a full curve. The brighter components of the systems are plotted in the figure as open circles, fainter components as filled circles and mean components as half-filled circles. The two components of ADS 1598 and 10227BC are connected by straight lines.

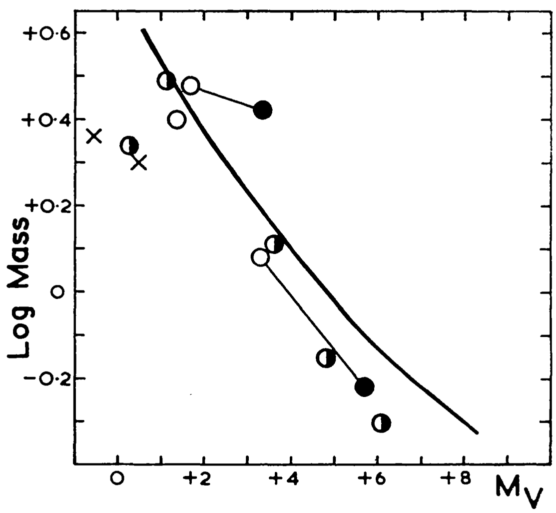

FIG. 10.—*Masses and luminosities of group binaries. The continuous curve is the normal mass-(visual) luminosity relation. Open circles represent primary components of visual binaries and filled circles the secondary components. The half filled circles are mean components for visual binaries with a small magnitude difference between the components. Straight lines connect components of the same system; the unconnected open circle represents Sirius. The two crosses represent the bright component of α CrB and the mean component of β Aur.*

The deviation from the normal relation of the group stars with $M_V = +3^m$ to $+6^m$ is very similar to that found previously (Paper VII, Fig. 8) for the Hyades group binaries. In fact, a mean mass–luminosity relation for the stars of both groups with luminosities in this range indicates that the Sun, $M_V = +4^m\cdot8$, is almost exactly one magnitude fainter than group stars of the same mass.

Among the brighter stars, three fall near the normal relation—the bright component of 48 Cas, the mean component of ζ UMa Aa, and Sirius—but the mean component of ζ Boo is nearly two magnitudes brighter, and the secondary of 48 Cas nearly two magnitudes fainter, than predicted by that relation.

Two additional, little observed binaries in the group deserve attention; W 6440 (ADS 7674), which is in rapid motion, and W 13854 (ADS 15578).

5. *The eclipsing binaries β Aur, α CrB and RR Lyn.*—Of the three known eclipsing variables in the group, double lines have been observed only in the spectra of β Aur. The two components are of equal mass, 2·3 ⊙ (Popper 1959), and equal luminosity, $M_V = -0^m\cdot54$, and are the brightest members for which a mass determination is available; the mean mass and luminosity are represented in Fig. 10 by a cross.

In a discussion of photoelectric observations with a red-sensitive photocell of the single-lined binary α CrB, Kron and Gordon (1953) found a 4^m difference between the components at λ7230. The secondary component is probably a

G-type dwarf so that the visual magnitude difference is $<4^m$. The visual luminosity of the secondary is then $M_V > +4^m\cdot5$ and, from the run of the mass–luminosity relation for the group stars in Fig. 10, the mass is $<0\cdot8\odot$. The mass function, $0\cdot063\odot$, given by Kron and Gordon, then yields a mass of $\leqslant 2\odot$ for the bright component; the upper limit for this mass is shown in Fig. 10 as a cross.

Stebbins and Huffer (1931) have published a light curve ($\lambda 4500$) of the single-lined binary RR Lyn. A new solution of this curve, based on an assumed value of 0·6 for the limb darkening coefficient of both components, gives the following elements:

$$i = 86^\circ\cdot5 \pm 0^\circ\cdot4 \text{ (p.e.)} \qquad a_1 = 9\cdot2 \times 10^6 \text{ km}$$
$$k = 0\cdot075 \pm 0\cdot006 \qquad L_1 = 0\cdot63 \pm 0\cdot04$$
$$r_1 = 0\cdot075 \pm 0\cdot006 \qquad L_2 = 0\cdot37 \pm 0\cdot04.$$
$$r_2 = 0\cdot071 \pm 0\cdot004$$

The mass function, $0\cdot31\odot$ (Harper 1915), and the normal mass–luminosity relation are satisfied by masses of $2\cdot3\odot$ and $1\cdot7\odot$ for the primary ($M_V = +2^m\cdot2$) and secondary ($M_V = +2^m\cdot8$), respectively. More definite information about the masses of these stars is especially desirable because the brighter component is a metallic-line star. If the luminosity difference derived from the light curve is correct the secondary component might be detectable by modern spectroscopic observations.

The masses and luminosities of both Sirius and Hyades group binaries give a strong indication that for $M_V < +3^m$ there is not a unique mass–luminosity relation. Although the deviation of the fainter component of 48 Cas ($M_V = +3^m\cdot4$) from the normal relation in Fig. 10 could be explained as either an error in the mass function, 0·3 instead of 0·43 (Kent 1950), or by the assumption that this star is itself double ($\text{mass}_1 \approx \text{mass}_2 \approx 1\cdot3\odot$), the nearly equal masses of β Aur, ζ Boo and, probably, α CrB, all giving large deviations from the normal relation, are unlikely to be the result of erroneously assuming that they are group members.

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References

Babcock, H. W., 1958, *Ap. J.*, *Supp.* No. 30.
de Vaucouleurs, A., 1957, *M.N.*, **117**, 449.
Dyer, E. R. Jr., 1954, *A.J.*, **59**, 221.
Eggen, O. J., 1955, *A.J.*, **60**, 131.
— 1956, *A.J.*, **61**, 361.
— 1957, *A.J.*, **62**, 45.
— 1958, *M.N.*, **118**, 65.
— 1959a, *M.N.A.S.S.A.*, **18**, 91.
— 1959b, *Obs.*, **79**, 197.
— 1960a, *M.N.*, **120**, 448, Paper VI.
— 1960b, *M.N.*, **120**, 540, Paper VII.
Greenstein, J., 1953, *Ap. J.*, **117**, 269.
Harper, I. W., 1915, *Pub. Dom. Obs.*, **2**, 127.
Herbig, G. H., and Spalding, J. F., 1955, *Ap. J.*, **121**, 118.

Hynek, J. A., 1951, *Astrophysics*, London.
Johnson, H. L., and Knuckles, C. F., 1957, *Ap. J.*, **126**, 113.
Kent, J. T., 1950, *A.J.*, **55**, 243.
Kron, G. E., and Gordon, K. C., 1953, *Ap. J.*, **118**, 55.
Naur, P., 1955, *Ap. J.*, **122**, 182.
Petrie, R. M., and Moyls, B. N., 1953, *M.N.*, **113**, 239.
Popper, D., 1959, *Ap. J.*, **130**, 130.
Roman, N. G., 1949, *Ap. J.*, **110**, 205.
Sandage, A. R., 1958, *Stellar Populations*, Spec. Vat., **5**, 41.
Sandage, A. R., and Eggen, O. J., 1959, *M.N.*, **119**, 278.
Slettebak, A., 1954, *Ap. J.*, **119**, 146.
— 1955, *Ap. J.*, **121**, 653.
Stebbins, J., and Huffer, C. M., 1931, *Pub. Washburn Obs.*, **15**, part 4.
Stebbins, J., and Whitford, A. E., 1945, *Ap. J.*, **102**, 1.
Stebbins, J., and Kron, G. E., 1956, *Ap. J.*, **125**, 440.
Stoy, R. H., 1953, *Cape Mimeogram* No. 1.
Wilson, O. C., and Bappu, M. K. Vainu, 1957, *Ap. J.*, **125**, 661.
Wilson, R. E., 1953, *General Catalogue of Stellar Radial Velocities*, Papers of the Mount Wilson Obs. **8**.
Vyssotsky, A. N., 1956, *A. J.*, **61**, 201.