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COMMUNICATIONS FROM THE OBSERVATORY AT LEIDEN

The concentration of the motions of A- and F-type stars around the velocity of the Ursa Major cluster, by *J. Delhaye.*

A study of the concentration of the space velocities of the A and F stars around the Ursa Major cluster velocity indicates the existence of a preferential motion in that direction, with a dispersion between 2 and 3 km.sec^{-1} in one co-ordinate.

It is well known that stars of early type show a tendency for moving in clusters, the members of which have the same velocity and are either very near to each other in space or more dispersed. Among these is the widely dispersed Ursa Major cluster. It has been studied by a great number of authors since its discovery by PROCTOR and HERTZSPRUNG. A list of the principal articles dealing with it is given at the end of the present paper.

The lists of members given by these authors are very different, according to the criteria adopted for membership. SMART, after a re-examination of the proposed members, retained 42 definitive and 52 doubtful members of the cluster. Miss N. G. ROMAN has examined that question anew and she has published a summary of her results [1]), according to which the cluster is formed by a nucleus containing 11 stars within 9 parsecs, the remaining stars being within 135 parsecs from the nucleus, and the whole cluster containing 32 definite and 12 probable members, with possibly several others in the region south of − 30°, which was not considered by the author.

This great extension in space of the Ursa Major cluster is known since HERTZSPRUNG [2]) had added to the five stars β, γ, δ, ε, ζ UMa, primarily recognised as members of the cluster, a few stars, among which was Sirius, and it has hitherto been accepted by all the authors as a fact of observation and a particular property of the Ursa Major cluster.

The present work has been performed during a stay at the Leiden Observatory, as a tentative discussion of that property, according to suggestions of Prof. J. H. OORT. The great number of members found in the different investigations and their great dispersion in space might suggest the existence among the early-type stars of a certain proportion of stars moving in a direction near to that of the Ursa Major nucleus. This possibility also appears in an investigation by STRÖMBERG in 1923 [1]).

The aim of this work is to study that question.

The Leiden material of space velocities.

A material of space velocities is available at the Leiden Observatory; it has been computed during the war years by Dr J. E. Baron DE VOS VAN STEENWIJK. Dr DE VOS VAN STEENWIJK had also made a preliminary discussion of this material and of the Ursa Major stream. This material contains the galactic components of the velocities relative to the sun of about 2000 stars, brighter than $6^{m}\cdot5$.

The proper motions were taken from the General Catalogue of B. Boss, with application of SMART's systematic corrections [2]); the parallaxes, from the material of spectroscopic parallaxes of ADAMS and his associates at the Mount Wilson Observatory[3]), with application of VAN RHIJN's corrections [4]); the radial velocities, from different sources [5]).

The components, designated by u, v, w, correspond to the directions $l = 0$, $b = 0$; $l = 90°$, $b = 0$; $b = 90°$, respectively.

The Ursa Major velocity.

After Sirius had been recognised as a member of the cluster, the determinations of the position of the apex

[1]) See Bibl. XIX.
[2]) See Bibl. III.

[1]) G. STRÖMBERG, *Mt Wilson Cont.* No. 257; *Ap.J.* **57**, 77 (1923).
[2]) W. M. SMART, *M.N.* **101**, 37 (1940).
[3]) W. S. ADAMS, A. H. JOY, M. L. HUMASON and A. M. BRAYTON, *Mt Wilson Cont.* No. 511; *Ap.J.* **81**, 187 (1935).
[4]) P. J. VAN RHIJN, *Groningen Publ.* No. 49 (1939).
[5]) J. H. MOORE, *Lick Publ.* **18** (1932).
V. A. ALBITZKY and G. A. SHAJN, *Publ. Poulkovo* série II, vol. **43** (1933).
W. E. HARPER, *Publ. Dom. Astr. Obs. Victoria* **6**, 151; *Publ. Dom. Astr. Obs. Victoria* **7**, 1.
R. F. SANFORD and P. W. MERRILL, *Mt Wilson Cont.* No. 591; *Ap.J.* **87**, 517 (1938).
W. H. CHRISTIE and O. C. WILSON, *Mt Wilson Cont.* No. 593; *Ap.J.* **88**, 34 (1938).
R. K. YOUNG, *Publ. David Dunlap Obs.* **1**, No. 3 (1939).

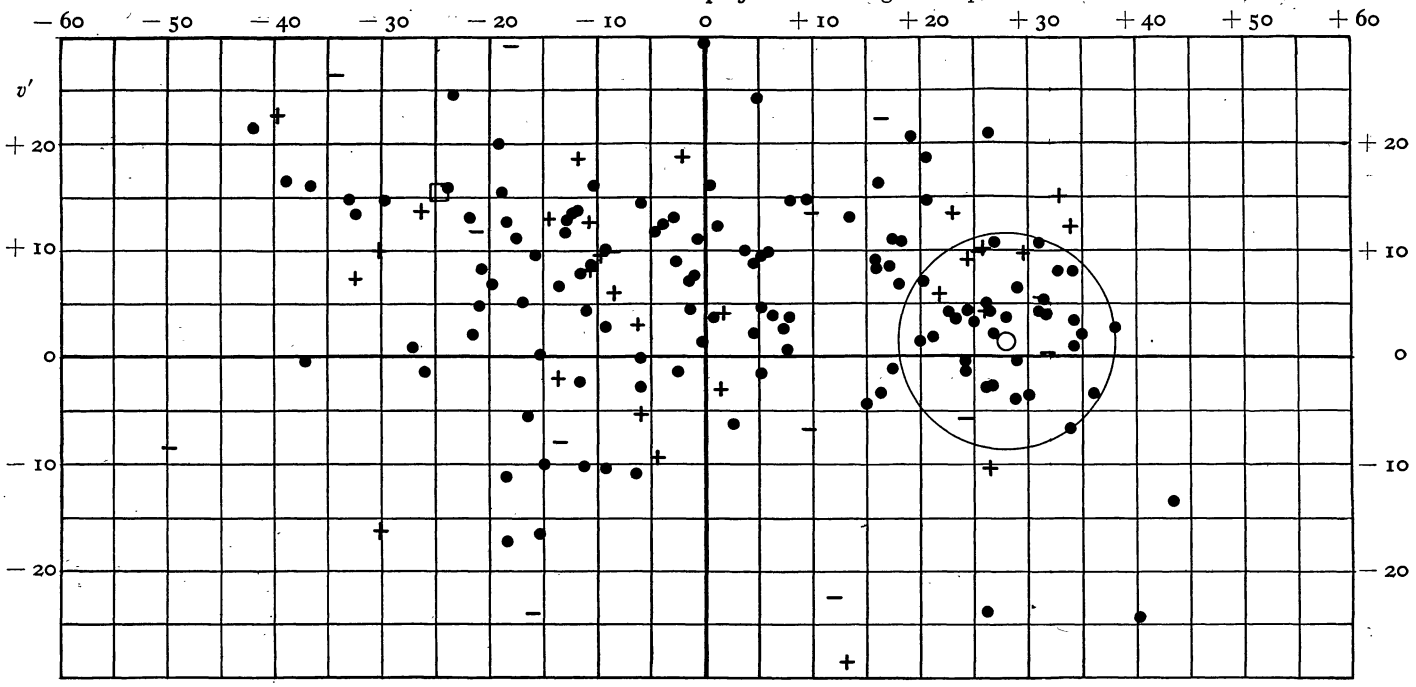


FIGURE 1. Velocities of A stars projected on the galactic plane.

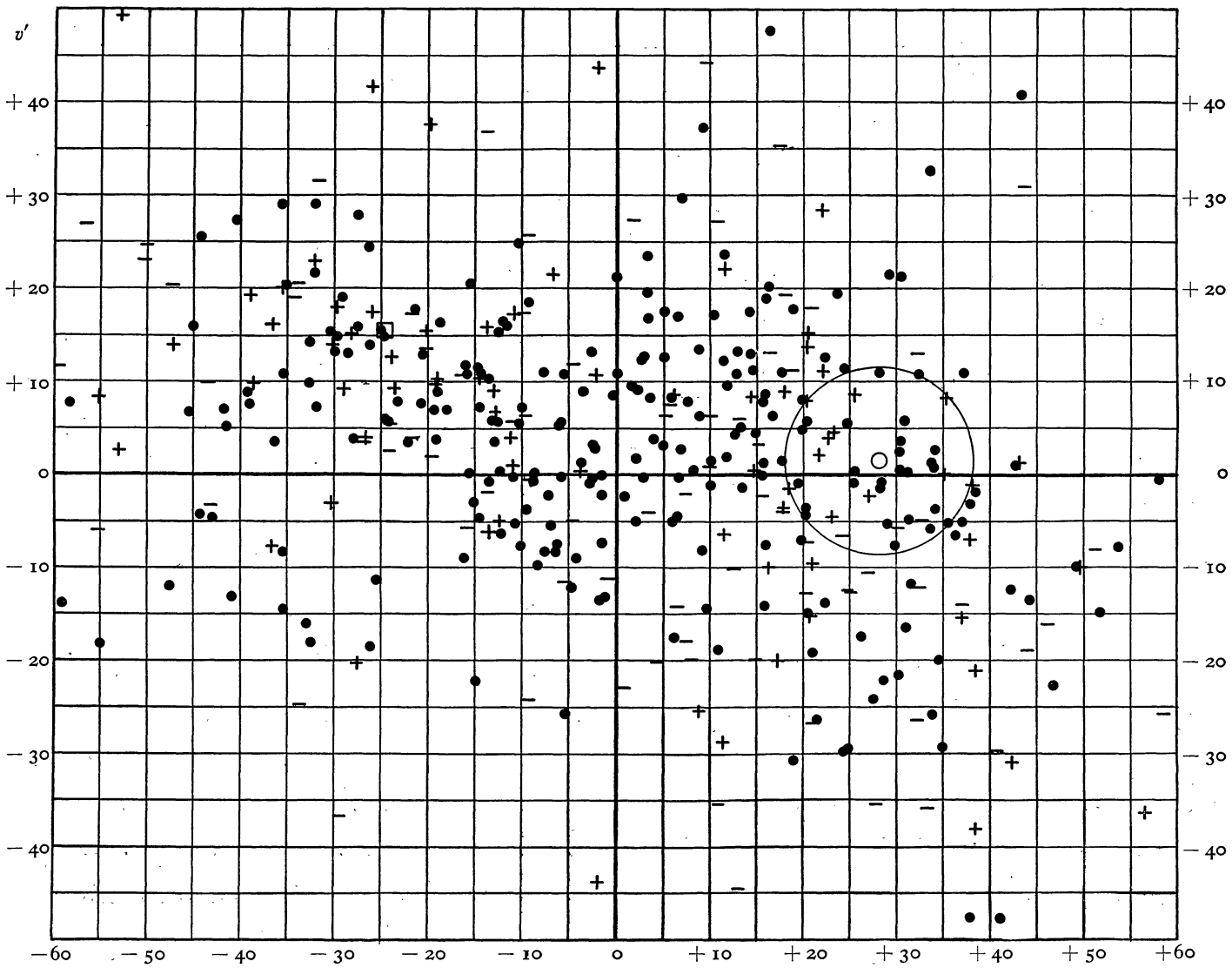


FIGURE 2. Velocities of F stars projected on the galactic plane.

and of the velocity were based on the membership of Sirius. For the present work it has been necessary to adopt the apex and the velocity computed from the members of the nucleus alone. These data were computed and kindly communicated by Miss N. G. ROMAN, who finds the following convergent and velocity relative to the sun:

$$A = 307°.3,$$
$$D = -37°.7,$$
$$V = 15.8 \text{ km. sec}^{-1}.$$

The velocity is uncertain because of a discrepancy between the results from radial velocities and parallaxes respectively. The position of the apex is little affected by this uncertainty.

The concentration of the velocities around the Ursa Major velocity.

This investigation concerns the stars of types Ao—A9 and Fo—F9, designated as A and F stars respectively.

Figures 1 and 2 show the space velocities projected on the galactic plane. The velocities u', v', w', plotted are the velocities corrected for the motion of the sun, for which I have assumed:

$$u'_\odot = +17.0 \text{ km. sec}^{-1},$$
$$v'_\odot = +7.4,$$
$$w'_\odot = +7.3.$$

The third component has been indicated with the following symbols: the velocities of which the w'-component is between -10 km. sec^{-1} and $+10$ km. sec^{-1} are designated by a dot. If w' is greater than $+10$ km. sec^{-1}, the velocity is indicated by the sign +, and if w' is smaller than -10 km. sec^{-1}, by the sign —. The velocity of the Ursa Major nucleus is indicated by an open circle, and the open square designates the velocity of the Hyades cluster, the components being in km. sec^{-1}, respectively:

	u'	v'	w'
UMa	+28.1	+1.5	−2.2,
Hya	−24.6	+15.4	+4.8.

The members of the nucleus according to Miss ROMAN's list, present in the material, and the members of the Hyades according to SMART's paper [1]) have been excluded from the diagrams. Several stars could

TABLE 1

Nucleus stars present in the material (all of type A)

HD	GC	α_{1950}	δ_{1950}	u km.sec^{-1}	v km.sec^{-1}	w km.sec^{-1}
		h m	° ′			
91480	14527	10 32.0	+57 20	+13.3	−4.7	−7.5
95418	15145	58.8	+56 39	+14.4	−4.7	−7.6
113139	17664	12 58.6	+56 38	+21.3	−4.9	−6.4
116656	18133	13 21.9	+55 11	+19.7	−7.8	−9.3
116657	18134	21.9	+55 11	+21.1	−9.0	−7.9

[1]) W. M. SMART, *M.N.* **99**, 168 (1939).

TABLE 2

Hyades stars present in the material

HD	GC	α_{1950}	δ_{1950}	u km.sec^{-1}	v km.sec^{-1}	w km.sec^{-1}
			TYPE A			
		h m	° ′			
25202	4807	3 57.9	+18 03	−59.8	+7.8	−1.8
27176	5189	4 15.4	+21 28	−34.5	+1.4	+1.6
27459	5252	17.8	+14 59	−42.2	−2.6	+6.7
27749	5315	20.5	+16 40	−48.4	+0.1	+3.6
27819	5328	21.2	+17 20	−41.6	+6.2	−2.8
27901	5344	22.0	+18 56	−44.3	+2.7	−1.1
27934	5350	22.4	+22 11	−41.0	+13.9	−6.8
27946	5351	22.4	+22 05	−40.2	−0.4	+0.7
27962	5354	22.6	+17 49	−43.4	+3.8	+1.6
28024	5370	23.3	+22 42	−38.2	+6.5	−1.8
28226	5412	25.0	+21 31	−38.1	+18.5	+13.1
28294	5425	25.6	+14 38	−58.9	+7.6	−1.2
28319	5436	25.8	+15 46	−49.8	+5.6	−0.4
28355	5443	26.0	+12 56	−40.5	+3.2	+3.2
28485	5467	27.3	+15 32	−40.8	−4.1	+7.5
28527	5480	27.7	+16 05	−45.1	+3.9	+0.7
29375	5643	35.3	+15 56	−44.2	+5.0	+0.8
29388	5645	35.4	+12 25	−51.9	+12.0	−5.0
29499	5665	36.4	+7 46	−37.7	+2.1	+6.4
30034	5767	41.7	+11 03	−45.0	+4.2	+1.5
30210	5802	43.2	+11 37	−43.7	+5.8	+1.9
30780	5907	48.4	+18 45	−34.8	+2.7	+0.8
33254	6300	5 06.6	+9 46	−41.3	+5.6	+0.9
			TYPE F			
		h m	° ′			
24357	4677	3 50.3	+17 11	−55.4	−4.5	+9.7
25102	4790	56.9	+10 11	−48.7	+8.7	+0.3
25570	4883	4 01.2	+8 04	−47.3	+6.9	+7.3
26015	4964	4.9	+15 02	−46.6	+3.1	+2.2
26462	5042	8.7	+5 24	−52.7	+0.8	+11.0
26911	5137	12.9	+15 17	−52.2	−4.0	+6.7
27991	5356	22.8	+15 50	−45.4	+2.0	+1.8
28546	5482	27.8	+15 35	−50.1	+1.2	+4.5
28556	5483	27.8	+13 37	−50.2	+0.1	+4.2
31236	5984	52.0	+19 24	−36.7	+0.5	−0.5

TABLE 3

Stars with velocities exceeding the limits of the diagrams

HD	GC	α_{1950}	δ_{1950}	u km.sec^{-1}	v km.sec^{-1}	w km.sec^{-1}
			TYPE A			
		h m	° ′			
6763	1383	1 05.8	+5 23	+69.3	−32.7	−37.0
21770	4210	3 29.0	+45 53	+22.0	−40.8	−5.5
151199	22521	16 41.9	+55 47	−68.7	+75.0	−95.3
			TYPE F			
		h m	° ′			
10453	2069	1 39.3	−11 34	−1.0	−71.1	−9.2
14214	2770	2 15.4	+1 31	−50.5	+43.5	+15.7
15228	2946	2 24.7	+9 59	+70.3	−45.9	−21.3
33564	6455	5 14.3	+79 11	+56.1	+32.4	−74.4
46588	8711	6 37.7	+79 37	−83.1	+48.1	−97.4
78362	12646	9 06.8	+63 43	+13.4	−85.0	+85.6
83808	13366	9 38.5	+10 07	−118.0	+8.0	−80.3
91889	14582	10 34.0	−11 58	+35.7	−59.3	−37.3
106516	16731	12 12.6	−10 01	+7.0	−125.1	−88.0
119992	18605	13 43.4	+56 08	+33.1	−59.1	+23.1
124425	19188	14 11.1	−0 37	+56.0	−31.4	−20.9
128429	19695	14 34.3	−12 06	−184.1	+60.2	+74.7
136064	20532	15 14.1	+67 32	+40.1	−58.2	−23.7
136202	20591	15 16.8	+1 57	+66.7	−59.0	−11.6
142860	21408	15 54.1	+15 49	+33.1	−67.2	−30.6
182807	26825	19 23.4	+24 49	+43.9	−95.7	−24.6
201601	29591	21 07.9	+9 56	−23.0	−96.2	−96.4

not be entered on these diagrams because their velocities exceed the limits of the figures. The data corresponding to these three sets of stars are listed in Tables 1, 2 and 3.

A rapid examination of Figures 1 and 2 suffices to show that there are more velocities around the Ursa Major velocity than in the diametrically opposite part of the diagram. As this phenomenon is disturbed by the errors in the data, principally in the parallaxes, it seemed preferable to return to the proper motions and the radial velocities separately, after using the diagrams of the space velocities for the selection of the stars to be considered.

The selected stars are those the velocity points of which are contained in a sphere of radius 10 km. sec^{-1} and centred on the velocity point of the Ursa Major nucleus (that sphere is represented on the figures by its intersection with the u', v'-plane), namely 22 A and 13 F stars, which are given in Table 4, with the following data in the different columns:

(1) current numbers;
(2) numbers in the *General Catalogue* of B. Boss;
(3) numbers in the *Henry Draper Catalogue;*
(4), (5) magnitudes and spectral types from *M.W. C.* No. 511;
(6), (7) positions of the stars for 1950·0;
(8) corrected spectroscopic parallaxes π, as indicated above;
(9) angular distances λ to the convergent of the nucleus;
(10), (11), (12) galactic components of the space velocities relative to the sun, in km. sec^{-1};
(13), (14) annual proper motions, corrected according to SMART's tables;
(15), (16) observed position angles ψ_o, of the proper motions, and probable errors;
(17) position angles ψ_c calculated on the hypothesis that the stars belong to the cluster;
(18) residuals $\Delta\psi = \psi_o - \psi_c$;

TABLE 4

(1)	GC (2)	HD (3)	m (4)	Sp (5)	α_{1950} (6)	δ_{1950} (7)	π (8)	λ (9)	u (10)	v (11)	w (12)
					h m	° ′	″	° ′	km.sec^{-1}	km.sec^{-1}	km.sec^{-1}
1	1003	4813	5·2	F9	0 47·6	− 10 55	0·066	63 19	+ 16·6	− 13·2	− 12·4
2	1254	6116	5·9	A5s	1 0·1	+ 41 5	7	100 08	+ 17·1	+ 0·7	− 10·0
3	2424	12111	4·7	A6s	1 57·8	+ 70 40	22	122 49	+ 14·5	− 2·0	− 3·6
4	2668	13594	6·4	F2	2 10·8	+ 47 15	24	113 57	+ 11·2	− 8·9	− 13·6
5	3582	18519	6·2	A4s	2 56·3	+ 21 8	8	107 56	+ 11·0	− 3·7	− 5·3
6	6274	33111	2·9	A2n	5 5·4	− 5 9	66	116 10	+ 9·5	− 3·1	− 4·9
7	6411	33959	5·4	A7s	5 12·1	+ 32 38	14	139 49	+ 12·0	− 0·9	− 3·7
8	7197	38393	3·8	F6	5 42·4	− 22 28	100	108 11	+ 17·1	− 4·7	− 10·8
9	7419	39587	4·6	F9	5 51·4	+ 20 16	76	141 43	+ 13·3	− 4·9	− 8·7
10	7543	40183	2·8	A2n	5 55·9	+ 44 57	66	150 42	+ 13·1	− 10·9	− 7·3
11	8037	43244	6·5	A2n	6 13·9	+ 46 27	16	153 46	+ 9·9	+ 3·3	− 11·8
12	8833	48915	− 1·6	A2s	6 42·9	− 16 39	373	120 08	+ 12·0	− 7·7	− 11·8
13	11047	67483	6·3	F3	8 5·9	+ 13 47	14	155 30	+ 8·4	− 6·5	− 7·6
14	11199	68457	6·4	A7s	8 11·6	+ 60 32	14	157 04	+ 7·2	− 7·7	− 13·6
15	11338	69548	5·9	F2	8 16·4	+ 57 54	34	159 33	+ 12·0	− 12·7	− 3·0
16	11983	74228	6·2	A9s	8 40·5	+ 12 52	22	154 58	+ 15·7	+ 0·7	− 10·4
17	12406	76756	4·3	F0	8 55·8	+ 12 3	27	153 46	+ 13·3	− 6·9	− 5·7
18	12713	79028	5·5	F9	9 10·4	+ 61 38	55	155 22	+ 3·3	− 11·0	− 8·5
19	13559	85235	5·0	A3s	9 48·7	+ 54 18	16	158 36	+ 5·6	− 3·2	− 11·0
20	14107	89025	3·9	F0	10 13·9	+ 23 40	18	153 31	+ 13·4	− 3·8	− 13·4
21	17198	109799	5·4	F2	12 35·0	− 26 52	30	93 26	+ 11·4	− 8·2	− 12·6
22	19207	124675	4·9	A7n	14 11·7	+ 52 1	22	121 16	+ 9·8	− 5·2	− 17·1
23	19319	125451	5·3	F1	14 16·8	+ 13 14	31	100 29	+ 13·8	− 1·6	− 8·6
24	19777	129247	4·4	A2n	14 38·8	+ 13 57	36	93 36	+ 3·3	− 0·3	− 9·0
25	19825	129798	6·3	F4	14 40·8	+ 61 28	20	121 16	+ 16·7	− 6·1	− 9·4
26	20947	139006	2·3	A1n	15 32·6	+ 26 53	83	94 49	+ 7·4	− 3·0	− 3·9
27	25713	173654	5·7	A6s	18 43·9	− 1 1	18	43 56	+ 17·9	− 5·2	− 5·5
28	25862	174589	6·0	A6n	18 48·7	− 3 23	12	41 25	+ 11·8	− 11·3	− 3·7
29	28258	193592	6·0	A7s	20 17·2	+ 55 14	19	92 59	+ 4·2	− 5·5	− 2·9
30	28481	194943	5·0	F1	20 26·0	− 17 59	27	19 47	+ 16·9	− 6·7	− 8·8
31	30265	205765	6·3	A1n	21 35·0	− 0 37	14	40 00	+ 17·2	− 3·9	− 9·0
32	30872	209625	5·5	A8s	22 2·2	− 1 9	19	42 21	+ 17·2	− 6·3	− 16·7
33	31016	210459	4·4	A7n	22 7·8	+ 32 56	18	74 17	+ 6·3	− 3·8	− 3·4
34	31440	213320	5·2	A2s	22 28·0	− 10 56	12	37 43	+ 7·2	− 8·7	− 14·3
35	31943	216627	3·5	A3s	22 52·0	− 16 5	27	38 06	+ 14·0	− 3·1	− 13·8

(19), (20) observed radial velocities R_o and probable errors (all velocities are from MOORE's *Catalogue*, except the two marked with an asterisk, which are taken from *M.W.C.* No. 593);

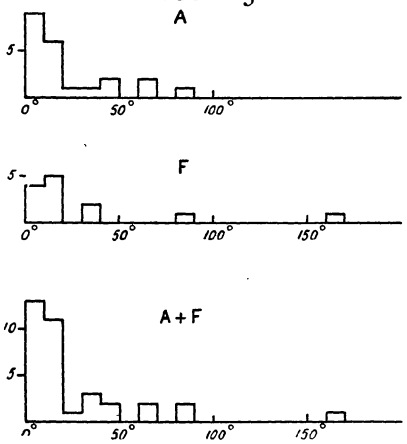
(21) radial velocities R_c calculated on the assumption that the stars belong to the cluster;

(22) residual radial velocities $\Delta R = R_o - R_c$.

Figures 3 and 4 give the distribution of the absolute values of the residual position angles and radial velocities. These distributions are given separately for the A and F stars, but the stars of the two types have been combined for the following investigation, because of their small number and the uncertainty of results based on each type separately.

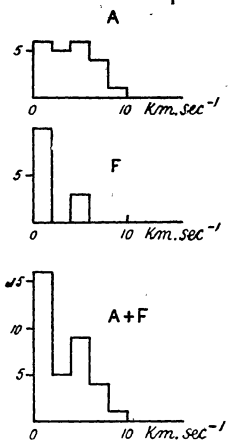
It is possible to compute the distributions of these residuals if the velocities of the stars considered are distributed following a given law around the Ursa Major velocity, and to compare those theoretical distributions with the observed. Because of the small

FIGURE 3



Distribution of the absolute values of the residual position angles.

FIGURE 4



Distribution of the absolute values of the residual radial velocities.

TABLE 4

$\mu_\alpha \cos\delta$ (13)	μ_δ (14)	ψ_o (15)	r_ψ (16)	ψ_c (17)	$\Delta\psi$ (18)	R_o (19)	r_R (20)	R_c (21)	ΔR (22)	(1)
″	″	°	°	°	°	km.sec^{-1}	km.sec^{-1}	km.sec^{-1}	km.sec^{-1}	
− 0·228	− 0·225	225·4	± 0·3	233·1	− 7·7	+ 7·7	± 0·3	+ 7·1	+ 0·6	1
− 19	− 11	239·9	6·8	228·0	+ 11·9	+ 3·3	0·7	− 2·8	+ 6·1	2
− 63	+ 4	273·6	1·8	248·8	+ 24·8	− 4·2	1·2	− 8·6	+ 4·4	3
− 62	− 61	225·5	2·3	239·6	− 14·1	− 8·3	0·8	− 6·4	− 1·9	4
− 14	− 6	246·8	3·8	235·7	+ 11·1	− 5·3	1·3	− 4·9	− 0·4	5
− 91	− 81	228·3	0·5	223·2	+ 5·1	− 7	3	− 7·0	0	6
− 20	+ 10	296·5	4·9	248·4	+ 48·1	− 9·7	(orb)	− 12·1	+ 2·4	7
− 283	− 374	217·1	0·2	213·7	+ 3·4	− 9·7	0·3	− 4·9	− 4·8	8
− 184	− 87	244·7	0·3	234·2	+ 10·5	− 13·6	0·2	− 12·4	− 1·2	9
− 52	− 4	265·6	0·9	270·7	− 5·1	− 18·1	(orb)	− 13·8	− 4·3	10
− 42	+ 14	288·4	3·7	277·1	+ 11·3	− 7·6	2·7	− 14·2	+ 6·6	11
− 533	− 1·212	203·7	0·1	204·2	− 0·5	− 7·5	(StndVel)	− 7·9	+ 0·4	12
+ 3	− 20	171·5	6·3	191·1	− 19·6	− 14·1*	1·9	− 14·4	+ 0·3	13
− 15	+ 5	288·4	9·7	350·9	− 62·5	− 16·2	1·0	− 14·6	− 1·6	14
+ 60	+ 11	79·6	1·8	352·6	+ 87·0	− 15·9	0·6	− 14·8	− 1·1	15
+ 1	0	90·0	∞	174·7	− 84·7	− 18·8	1·2	− 14·3	− 4·5	16
+ 39	− 35	131·9	0·9	168·0	− 36·1	− 13·5	0·5	− 14·2	+ 0·7	17
0	− 33	180·0	3·0	19·7	+ 161·3	− 14·0	(orb)	− 14·4	+ 0·4	18
− 5	+ 17	343·6	4·8	47·5	− 63·9	− 12·2	0·6	− 14·7	+ 2·5	19
+ 22	− 10	114·4	2·4	128·3	− 13·9	− 18·7	1·5	− 14·1	− 4·6	20
+ 77	− 98	141·8	1·2	135·9	+ 5·9	− 0·8	0·6	− 0·9	+ 0·1	21
+ 64	− 5	94·5	1·6	112·6	− 18·1	− 14·9	0·2	− 8·2	− 6·7	22
+ 107	− 34	107·6	1·1	126·5	− 18·9	− 1·9	0·6	− 2·9	+ 1·0	23
+ 55	− 23	112·7	1·0	127·3	− 14·6	− 6·2	1·2	− 1·8	− 4·4	24
+ 72	− 31	113·3	1·8	112·5	+ 0·8	− 6·8*	1·1	− 8·2	+ 1·4	25
+ 122	− 94	127·6	0·2	130·2	− 2·6	+ 1·0	(orb)	− 1·3	+ 2·3	26
+ 12	− 23	152·4	4·6	149·6	+ 2·8	+ 18	3	+ 11·4	+ 6·6	27
− 2	− 27	184·2	4·6	149·4	+ 34·8	+ 12	2	+ 11·9	+ 0·1	28
− 2	− 22	185·2	6·5	177·7	+ 7·5	− 2·8	0·7	− 0·8	− 2·0	29
− 14	− 25	209·2	1·9	178·1	+ 31·1	+ 19·5	1·1	+ 14·9	+ 4·6	30
− 16	− 21	217·3	5·5	200·4	+ 16·9	+ 16·9	1·7	+ 12·1	+ 4·8	31
− 16	− 50	197·7	2·2	207·6	− 9·9	+ 20·4	(orb)	+ 11·7	+ 8·7	32
− 8	− 22	200·0	3·0	200·1	− 0·1	+ 2·2	1·7	+ 4·3	− 2·1	33
+ 2	− 30	176·2	1·7	219·9	− 43·7	+ 13·7	0·6	+ 12·5	+ 1·2	34
− 38	− 24	237·7	1·3	228·4	+ 9·3	+ 18·0	0·7	+ 12·4	+ 5·6	35

number of stars, such a comparison can of course only be rough. The theoretical distributions were computed for each of the three following cases:

A. the velocities are evenly distributed in the sphere of radius 10 km. sec^{-1};

B. the velocities are distributed as follows: in a sphere of 10 km centred in the point opposite to the velocity of the Ursa Major nucleus on the diagrams, we find 8 stars. We assume consequently that the velocities of 8 stars are accidentally contained in our sphere, and are evenly distributed. It was further assumed that half of the remaining stars have velocities within a sphere of 5 km and the other half between that and the sphere of 10 km;

C. the velocities are distributed as in case B, but the sphere of 5 km is replaced by a sphere of 3 km.

These three cases are represented on Figures 5 and 6 for the residual position angles and for the residual radial velocities, respectively. The dots correspond to the observations and the curves to the three theoretical cases.

Both figures indicate that there is a real concentration of velocities towards the motion of the Ursa Major nucleus. At the same time they show that the velocities of the members of the extended Ursa Major stream are not identical, but have a real dispersion, the amount of which may be estimated as between 2 and 3 km. sec^{-1} in one co-ordinate.

These findings confirm, at least partly, the reality of the long lists of members of the Ursa Major cluster that have previously been published; only, the dispersion, both in space and velocity, is greater than that found in other clusters. It is possible to consider an alternative hypothesis: that of a preferential motion amongst the early-type stars in a direction near that of the velocity of the Ursa Major nucleus, the Ursa Major nucleus stars forming a small cluster, which follows that preferential motion.

The present data cannot be conclusive, but it is to be hoped that the increasing observational material will permit to solve the question.

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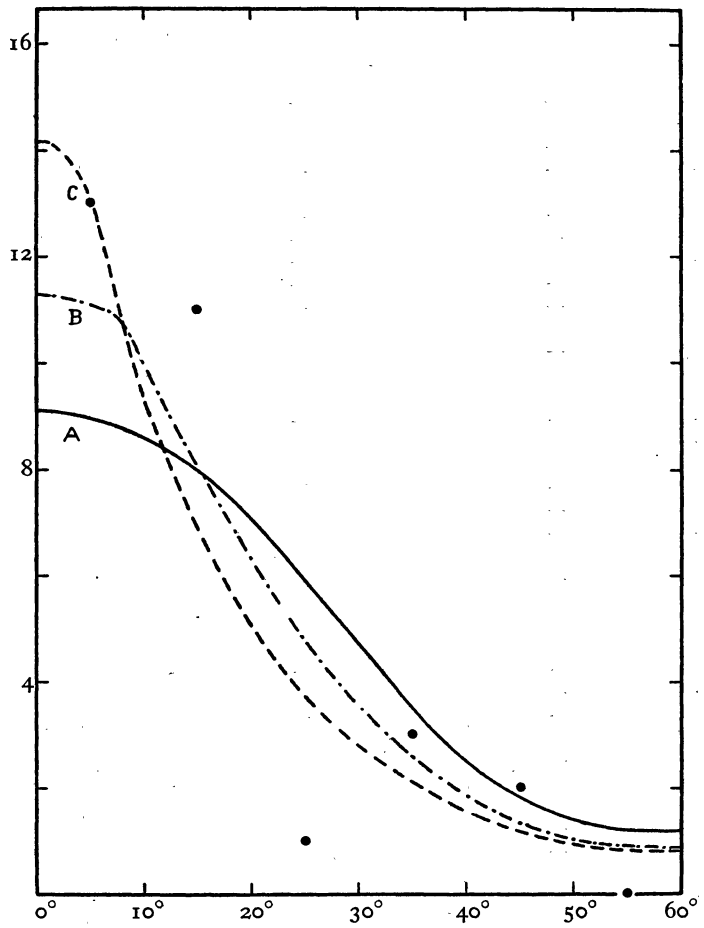
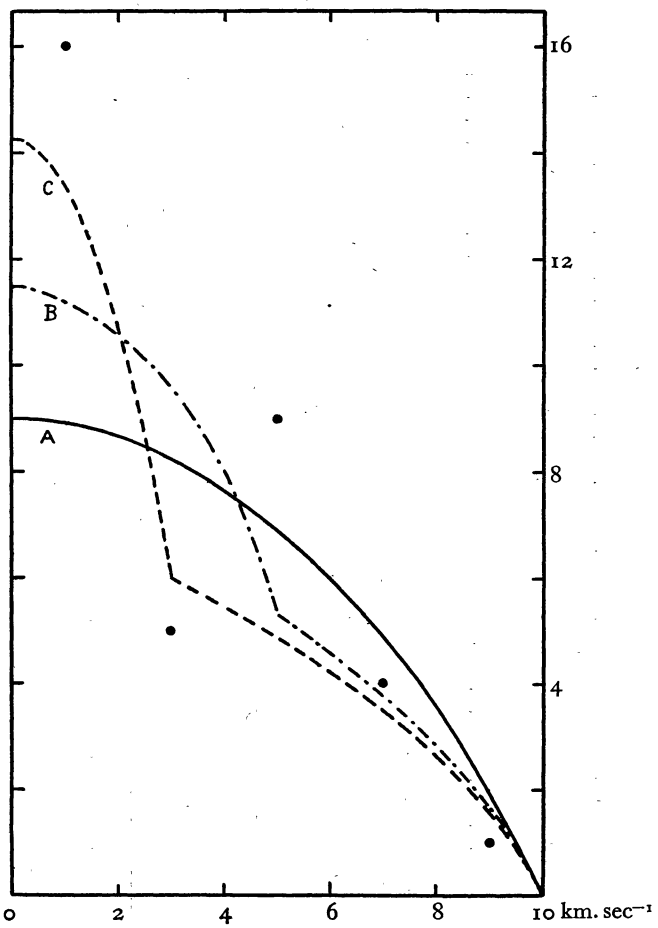
Figure 5



Comparison between the observed and the theoretical distributions of the residual position angles.

Figure 6



Comparison between the observed and the theoretical distributions o the residual radial velocities.