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ON THE STRUCTURE OF THE HYADES CLUSTER

BY H. G. VAN BUEREN¹⁾

The Yale repetition of the AG Catalogue has been used to make a complete search for members of the Hyades cluster down to 9^m.0 visual. These are listed in Tables 2a and 2b. For the great majority the membership could be verified with the aid of radial velocities, mostly taken from a list by R. E. WILSON. All further known Hyades members not occurring in the AG Catalogue, together with some members in the very outer region of the cluster and some doubtful cases, are listed in Tables 2c and 2d.

The vertex of the cluster motion has been redetermined, its co-ordinates for 1950 are:

$$\alpha_V = 6^h 18^m.5 \pm 2^m.1 \text{ (m.e.)}; \delta_V = +7^\circ 29' \pm 11' \text{ (m.e.)};$$

the velocity of the cluster is $43.95 \text{ km. sec}^{-1} \pm 0.60 \text{ (m.e.)}$. The distribution on the sky of the Hyades brighter than 9^m.0 visual is shown in Figure 4; there is some indication of real irregularities in this distribution. The general density distribution has been investigated for stars of different spectral types. It has been shown that, on the whole, the distribution resembles that which would correspond to statistical equilibrium, although there remain serious discrepancies, indicating that the age of the cluster is less than its relaxation time of about 10^8 years.

The total mass of the cluster is estimated to be about 320 solar masses, and the total number of members about 350. The average internal velocity in one co-ordinate should be $0.23 \text{ km. sec}^{-1}$ for a star of average mass; half of the mass of the cluster is concentrated in a sphere of about 6 parsecs radius with centre at $\alpha_c = 4^h 24^m \pm 1^m \text{ (m.e.)}; \delta_c = +15^\circ 45' \pm 15' \text{ (m.e.)}$ (1950), at a distance of $40.4 \text{ parsecs} \pm 1.1 \text{ (m.e.)}$ from the sun.

For stars brighter than 6^m.5 accurate new proper motions were furnished by Dr H. R. MORGAN from a combination of his new N30 motions with those of the GC and of the *New Washington Zodiacal Catalogue*. These have been used for determining individual parallaxes, and for a more accurate study of the space distribution (Figure 8). Again, large deviations from radial symmetry appear. The cluster seems to have a flattened shape; the equatorial plane is roughly parallel to the galactic plane, the galactic co-ordinates of its pole being $l_p = 242^\circ$; $b_p = +70^\circ$ (1950). The dispersion in the direction of the short axis is 2.2 ps, that in the direction of an axis in the equatorial plane 3.3 ps, corresponding to a flattening of 0.67.

Among the stars outside the general region of the cluster only slight evidence was found of a concentration of motions around that of the Hyades cluster: the evidence for the existence of a more general Taurus stream with small velocity dispersion is inconclusive.

A check was made of the large value of the internal motion of the stars in the central region of the Hyades found by VAN RHIJN and KLEIN WASSINK; this value was not confirmed.

1. The subject of this paper is twofold. In the first part (section 2) the motions of those A- and F-type stars and G- and K-type giants of which reliable space velocities are available will be examined and the concentration of these velocities towards the velocity of the Hyades will be investigated. The second part (sections 3 to 7) deals with the structure of the cluster itself.

For both parts a new determination of the motion of the Hyades cluster was necessary. Therefore the proper motions of the 72 stars considered by SMART²⁾ to be members were taken from Boss' *General Catalogue* and corrected for errors of the fundamental system and of the constants of precession according

to the tables given by BLAAUW and DELHAYE¹⁾.

Using the co-ordinates of the vertex given by SMART, residual position angles of the proper motions were computed. A least-squares solution from these residuals (which is free from regression error) yielded the following values of the co-ordinates of the vertex for 1950:

$$\alpha_V = 6^h 18^m.5 \pm 2^m.1 \text{ (m.e.)}; \delta_V = +7^\circ 29' \pm 11' \text{ (m.e.)}.$$

The velocity of the cluster has been redetermined from all radial velocities given in Table 2a of this paper, a complete list that will be described in section 3; its value was found to be

$$V = 43.95 \text{ km. sec}^{-1} \pm 0.60 \text{ (m.e.)}.$$

¹⁾ At present at the Philips Research Laboratories, N.V. Philips' Gloeilampenfabrieken, Eindhoven-Netherlands.

²⁾ W. M. SMART, *Monthly Notices R.A.S.* **99**, 168, 1939. In this paper also many references to earlier work on the Hyades may be found.

¹⁾ A. BLAAUW and J. DELHAYE, *B.A.N.* No 400, 1949. Corrections for galactic rotation are not applied throughout this paper.

2. About the extension in space of the Hyades cluster not much is definitely known. In order to investigate this question we examined the distribution of the motions of the stars for which reliable space velocities could be found. A list of such velocities is available at the Leiden Observatory; it was computed during the war by Dr J. E. baron DE VOS VAN STEENWIJK. The list contains the galactic components of the velocities relative to the sun of about 2000 stars brighter than $6^m.5$. More particulars about this material may be found in the paper by J. DELHAYE¹⁾ on the concentration of the motions of the A- and F-type stars around the velocity of the Ursa Major cluster; this section runs nearly parallel with that article.

The galactic components of the velocity of the Hyades cluster, with respect to the origin used by DELHAYE²⁾ are $u' = -25.1$; $v' = +15.5$, $w' = +5.4$ km. sec⁻¹.

In Figures 1 and 2 of DELHAYE's paper the distributions of the projected velocities on the galactic plane are shown for the A and F stars. The open square represents the Hyades velocity. It is seen at a glance that there are many more velocities around the Hyades velocity than in the diametrically opposite part of the diagram. A similar diagram for stars of other types does not show such a pronounced difference. Only the G- and K-type giants show a similar asymmetry, and are therefore included in the further discussion.

We have selected those velocity vectors which point into a sphere of radius 10 km.sec⁻¹ around the velocity of the Hyades. Leaving out the members of the cluster itself (as listed by SMART), we find the following numbers of velocities within the sphere:

spectrum:	A	F	G	K
number:	4	18	13	16

As the space velocities are affected by large errors, principally due to the uncertainty of the parallaxes, we returned for these stars to the proper motions and the radial velocities separately. The HD numbers of the stars selected are given in Table 1.

For all of these stars the residual position angles and the residual radial velocities (the differences between the observed values and those theoretically expected) were computed.

The distribution of the absolute values of the

¹⁾ B.A.N. No 395, 1948.

²⁾ This origin corresponds with the solar motion

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

The components of the cluster velocity were computed from values of the co-ordinates of the vertex and of the velocity slightly different from those given in section 1, as better data were not yet available. This has no consequences, however, for the results of this section.

TABLE I

HD numbers of stars with velocity vectors pointing into a sphere of 10 km.sec⁻¹ around the velocity of the Hyades. Members of the cluster according to SMART have been excluded.

HD	HD	HD	HD	HD	HD
18404	38710	73710	111998	163532	206546
19787	39007	74874	113022	169916	210434
20675	49161	75732	113226	172748	212754
24546	50877	76943	116976	173880	216380
25998	55751	79554	127739	185912	222493
29169	59148	83332	148786	187915	222643
33167	62576	94402	156015	194152	
33204	65759	96616	160835	204381	
34029	73665	109217	160910	206088	

residual position angles and of the residual radial velocities is given in Figures 1 and 2. Theoretical computations of these distributions have been made based on three different assumptions, of which only the first one was applied to the residuals for the G and K giants.

a) The velocities are evenly distributed within the sphere of radius 10 km.sec⁻¹.

b) In a sphere centred in a point opposite to the Hyades vertex, we find 6 A and F stars. Consequently we assume an even distribution of 6 velocities in our sphere. Half of the remaining velocities are supposed to be evenly distributed in a sphere of radius 5 km. sec⁻¹, and the other half between that and the sphere of 10 km.sec⁻¹.

c) As in case b, the sphere of 5 km.sec⁻¹ being, however, replaced by a sphere of 3 km.sec⁻¹ radius.

The three theoretical distributions for the A and F stars, and the one distribution for the giants are represented in Figures 1 and 2 by various curves. The graphs indicate a slight concentration of the velocities selected towards the motion of the Hyades cluster, especially in the case of the A and F stars. Besides, for all types there is a slight indication that the number of stars with large residual position angles is somewhat smaller than the number expected theoretically.

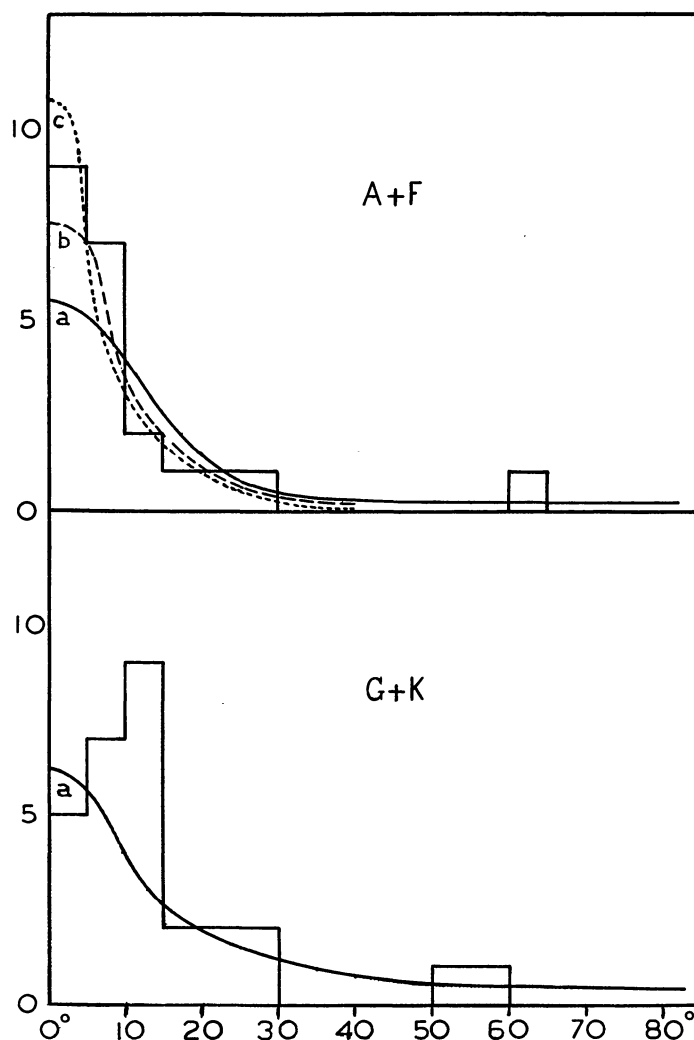
Hence, little can be inferred from these data with respect to the existence of a more general stream of the Hyades. The possibility of the existence of such a general stream was first mentioned by STRÖMBERG¹⁾. Studying the distributions of the velocities of the stars of spectral types F to M, and A, that author found an indication of a general Taurus stream, to which 18.5 per cent of the stars of spectral type A7 to F9 with absolute magnitudes between $0^m.0$ to $5^m.5$, and about 8 per cent of the stars of spectral type B2 to A7 would belong.

The well-known parallelism of the motions of the

¹⁾ *Ap.J.* 56, 265, 1922 and *Mt Wilson Contr.* No 245.

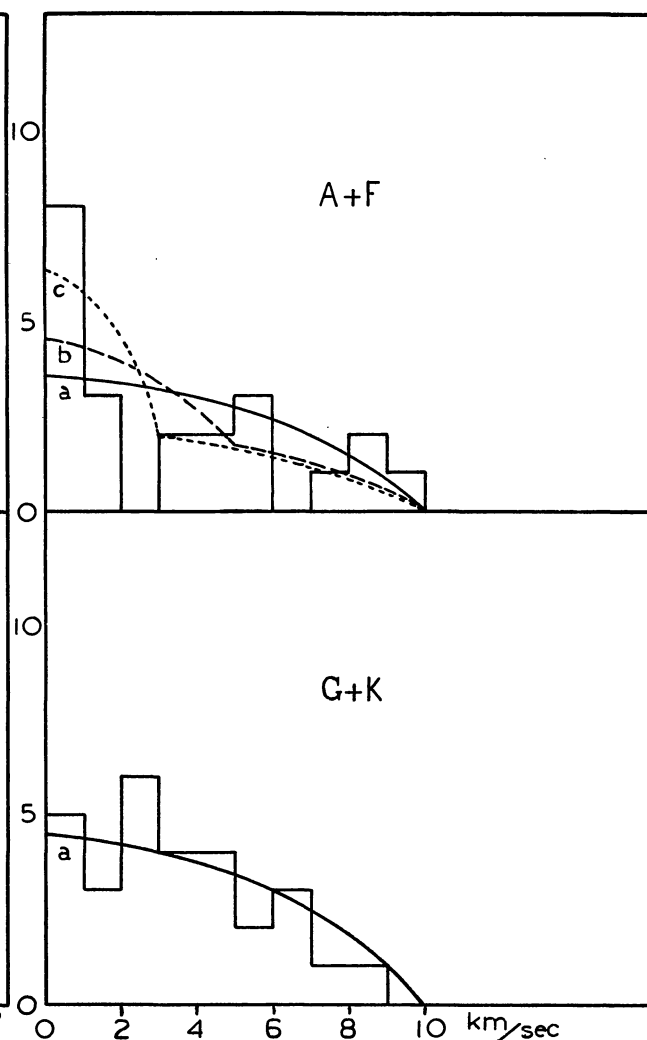
Ap.J. 57, 77, 1923 and *Mt Wilson Contr.* No 257.

FIGURE 1



Distribution of the residual position angles of the stars in Table 1. For the meaning of the different curves we refer to the text.

FIGURE 2



Distribution of the residual radial velocities of the stars in Table 1. The different curves have the same meaning as in Figure 1.

Praesepe cluster and the Hyades¹⁾ may be a feature of this stream. When correcting the proper motion of Praesepe according to the tables of BLAAUW and DELHAYE its position-angle is found to be $20^{\circ}.6 \pm 1^{\circ}.4$ (p.e.). If the motion of Praesepe were parallel to that of the Hyades, this position-angle should be $14^{\circ}.9 \pm 0^{\circ}.7$. In this case the radial velocity of Praesepe would be 35.6 km.sec^{-1} ; its real value is $33.8 \text{ km.sec}^{-1} \pm 0.7$ (p.e.), the weighted mean of four reliable observed velocities²⁾.

3. In order to obtain a homogeneous and complete

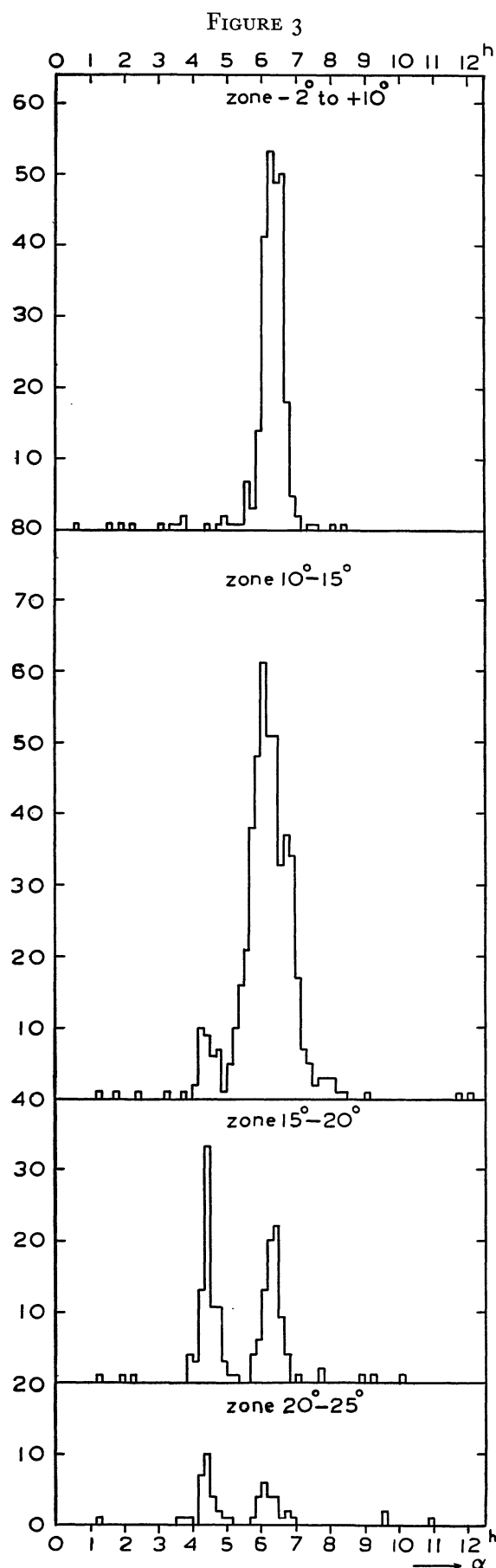
¹⁾ See for instance: W. J. KLEIN WASSINK, *Publ. Kapteyn Astr. Lab. Gron.* No 41, 1927.

²⁾ Prof. HERTZSPRUNG drew my attention to the star Groombridge 34 = ADS 246 = GC 358, the proper motion of which agrees remarkably well with the Hyades velocity (the residual position angle is $+33'$). The velocity, however, differs 30% from the Hyades velocity. This star may also be an indication of a general Taurus stream.

list of members of the Hyades cluster, a search was made for all stars in the Yale repetitions of the AG Catalogue¹⁾ having proper motions corresponding to the velocity of the Taurus cluster.

The Yale zones contain proper motions of all stars brighter than the 9th visual magnitude. Although the probable errors of these proper motions are rather large, this does not seriously affect the result of a search for members of the Taurus cluster, because of its large mean proper motion. In most cases the probable errors do not exceed 10% of the mean proper motion of the cluster. The eight zones between -2° and $+30^{\circ}$ were examined. The selection of the stars was made as follows: For each zone a graph was constructed giving the theoretical values of μ_a and μ_δ as functions of the co-ordinates of the star. We assumed

¹⁾ *Transactions Yale Astr. Obs.* Vols. 9, 1933; 10, 1934; 18, 1947; 19, 1948; 20, 1949; 21, 1950; 22, 1950.



that as a consequence of accidental errors a deviation of three times the probable error of each component from the theoretical value was still acceptable. Moreover a distance scatter of 20% for the cluster members had to be tolerated.

All stars having proper-motion components within the limits defined above, were listed. In Figure 3 the distribution of these stars in right-ascension is plotted for the zones between -2° and $+25^\circ$ declination. In the zone $+25^\circ$ to $+30^\circ$ there are only few stars which satisfy the requirements. The ordinates give the numbers of stars per interval of 10 minutes in α . There are two peaks in the curves. The first peak is centred at about $\alpha = 4^h 25^m$: this is the right-ascension of the centre of the Hyades. The stars belonging to this peak must be considered as members of the cluster. The second peak is centred at about $\alpha = 6^h 20^m$, the right-ascension of the vertex of the Hyades, and is caused by the fact that near the vertex every star with small proper motion falls within the limits specified for the selection. This second peak contains therefore spurious "Hyades" and must be excluded from the discussion. The declination of the vertex being $+7^\circ 29'$, this peak will be largest in the zones of lower declination. The separation between the peaks in these zones becomes rather difficult, especially in the zone $5^\circ - 10^\circ$. We have taken $\alpha = 3^h 0^m$ and $\alpha = 5^h 20^m$ as the limiting right-ascensions of the Hyades peak. By choosing these values we have good hope that not more than about five or ten stars included in the following discussion do not really belong to the Hyades, and most of these stars can be rejected if their radial velocities are known.

It is seen at once from the graphs that the Hyades brighter than 9^m are strongly concentrated in an area of about 20° diameter around the centre $\alpha = 4^h 25^m$, $\delta = +16^\circ$. Some fainter members have been found at larger distances, but they fall outside the scope of this work. The number of stars selected in the way mentioned amounts to 159. For 139 of these stars reliable radial velocities were known; 7 stars have velocities which exclude membership of the Taurus cluster, and have been rejected from the discussion.

In Table 2a are the remaining 132 certain members of the cluster, of which the radial velocities agree well with the cluster motion. Four stars immediately outside the limits of right-ascension mentioned above, which must be considered as probable members on the basis of proper motion and radial velocity, are given in the first section of Table 2c. The source from which

Distribution of stars in the Yale zone catalogues having proper motions corresponding to the velocity of the Taurus cluster. The peak centred around $\alpha = 6^h 20^m$ is caused by the fact that near the vertex of the Hyades every star with small proper motion falls within the limits specified for the selection of cluster stars. It contains therefore spurious "Hyades". The peak centred at about $\alpha = 4^h 25^m$ contains real members of the cluster.

the radial velocity is taken is indicated by a letter. These letters have the following meaning:

- W: R. E. WILSON, *Mt Wilson Contr.* No 741 and *Ap.J.* 107, 119, 1948. By far the greater part of the velocities have been taken from this extensive list.
- M: J. H. MOORE, *Publ. Lick Obs.* XVIII, 1932 (Catalogue of radial velocities).
- S: W. H. STILWELL, *Publ. Dom. Ap. Obs. Victoria* VII, No 22, 1945.
- H I: W. E. HARPER, *Publ. Dom. Ap. Obs. Victoria* VI, No 10, 1933.
- H II: W. E. HARPER, *Publ. Dom. Ap. Obs. Victoria* VII, No 1, 1937.
- SA: G. SHAJN and V. ALBITZKY, *Monthly Notices R.A.S.* 92, 771, 1932.
- CW: W. H. CHRISTIE and O. C. WILSON, *Ap.J.* 88, 34, 1938 and *Mt Wilson Contr.* No 593.
- DD: R. K. YOUNG, *Publ. David Dunlap Obs. Toronto* I, No 3, 1939.

For several stars more than one velocity determination was available; in these cases the mean velocity was given, or, if one of the determinations was much more accurate, this value was inserted, and the others were mentioned in a note. Also, important peculiarities of the stars are mentioned in the notes following the table. Those stars for which no radial velocities are known and three stars whose radial velocities do not agree with the cluster motion, but whose velocities are poorly determined, have been collected in Table 2b. The meaning of most columns will be clear without further explanation. The proper motions in columns 8 and 9 are those given in the Yale zone catalogues, except for the stars occurring in the *General Catalogue*, for which the motions were taken from this catalogue. For some brighter stars more accurate proper motions are available. Those stars are listed in Table 9 of section 6. They are indicated here by printing their designating number in italics. The Yale proper motions were reduced to the GC system with the aid of the systematic corrections valid for the different zones. These corrections are given in the introductions to the catalogues except for the zone $+20^\circ$ to $+25^\circ$ declination, for which they have been taken from an unpublished manuscript by G. M. CLEMENCE and P. HERGET, which was very kindly put at our disposal. For the zone $+25^\circ$ to $+30^\circ$ declination they were computed by the writer. To all proper motions the corrections for

change of fundamental system and of constants of precession (not for galactic rotation), computed by BLAAUW and DELHAYE (*l.c.*) have been applied.

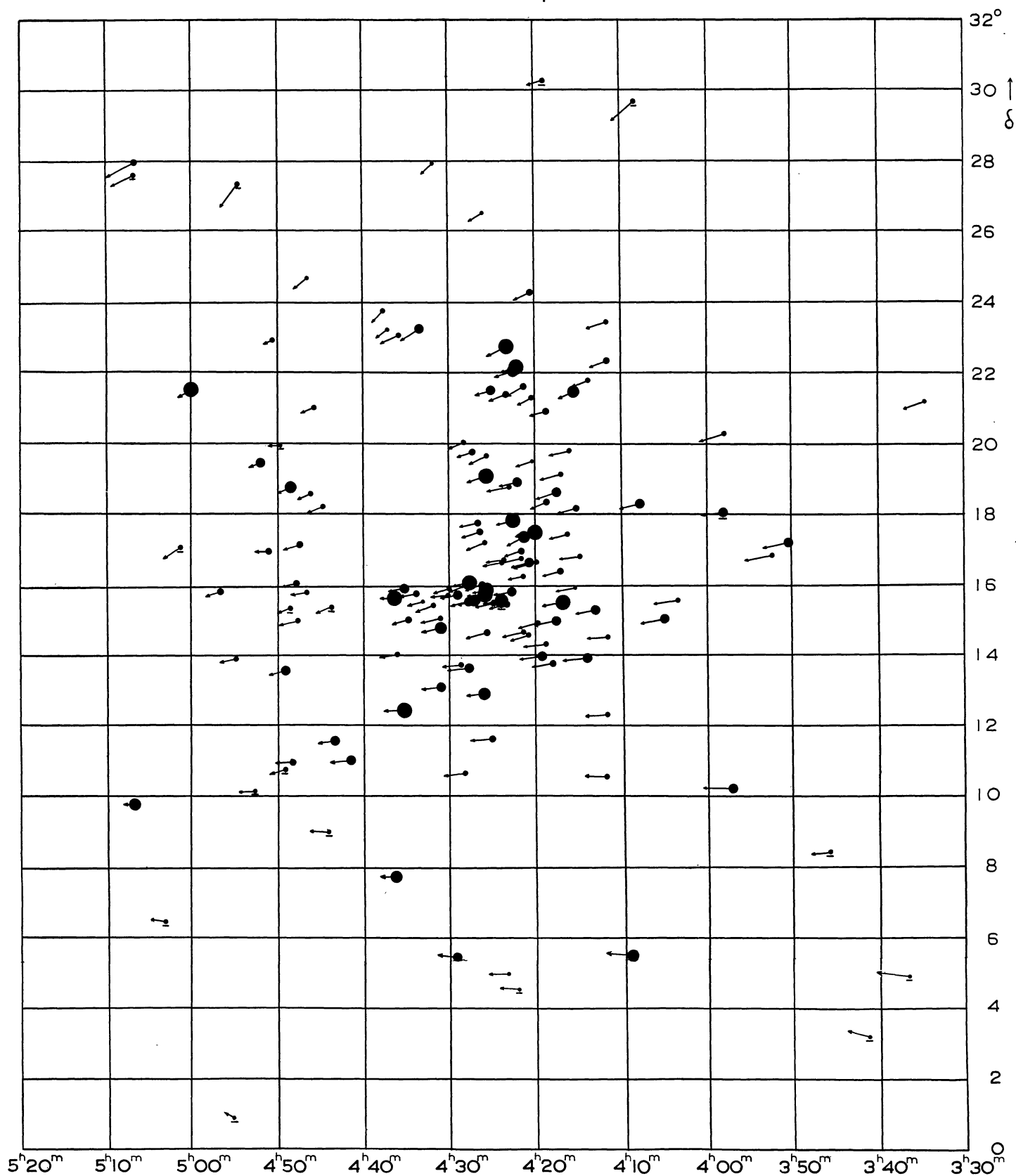
The 10th column of the table contains the total proper motion, the 13th the distance from the star to the vertex of the Hyades. The apparent magnitudes shown in column 6 are those given in the Yale zone catalogues or in the GC respectively; it was not deemed useful to replace them by the only slightly more accurate HD magnitudes. The apparent magnitudes can be transformed into absolute magnitudes by subtracting from them the mean distance modulus of the cluster, viz. $3^m.03$ (see section 6). Column 11 contains the observed position angles with their probable errors, column 12 the residual position angles. The radial velocities with their probable errors are given in column 14; column 15 gives the residual velocities. Asterisks refer to the notes.

It is pretty certain that not more than 1 or 2 of the stars listed is not a cluster member. We have compared our list with some other well-known lists¹⁾ of the Hyades, in order to check its completeness. In this comparison we encountered some doubtful cases, which had not been included in Tables 2a and 2b. These and the known Hyades below the limit of the AG Catalogue have been listed in Tables 2c and 2d. The first section of Table 2c contains the four stars beyond the limits of right-ascension mentioned above. In the second section are the doubtful cases in so far as they occur in the Yale catalogues, with their values of μ , $\Delta\psi$ and ΔV . In Table 2d are the stars fainter than the limit of the Yale catalogues. Most of these occur in the Groningen lists.

Figure 4 shows a map of all stars contained in Tables 2a and 2b, except the stars 1, 2, 3, 4 and 133, which fall outside the limits of the diagram. The dots referring to stars of Table 2b have been underlined. They occur mostly in the outer regions, and must be considered with some reserve. The amounts and directions of the proper motions have been indicated by arrows. The distribution shown in the figure seems more irregular than we would expect in a cluster where the stars are distributed at random. The structure of the cluster appears still to reflect the irregularity of the mass of gas from which it must have originated. From the densest part near $\alpha = 4^h 25^m$, $\delta = +16^\circ$ the cluster seems to extend in northerly

¹⁾ P. J. VAN RHIJN and W. J. KLEIN WASSINK, *Publ. Kapteyn Astr. Lab. Groningen* No. 35, 1924; W. GYLLENBERG, *Meddel. Lunds Astr. Obs.* Ser. II, No. 57, 1931; W. CHR. MARTIN, *B.A.N.* No. 256, 1934 and No. 274, 1936; R. E. WILSON (*l.c.*); W. M. SMART (*l.c.*).

FIGURE 4



Map of the Hyades brighter than $9^{m.0}$ visual. The size of the dots is a measure for the magnitude of the stars; the arrows show the annual proper motion ($1 \text{ mm} \approx ''/a.030$). Five stars in the very outer regions of the cluster are not shown on the map. Underlined dots indicate stars of which no radial velocity is known.

TABLE 2a

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	
No	BD	Yale or GC	α_{1950}	δ_{1950}	m_v	Sp	$\mu_\alpha \cos \delta$ p.e.	μ_δ p.e.	μ	ψ_0 p.e.	$\Delta\psi$	λ	$V_{\text{rad.}}$ p.e.	ΔV	
							unit $0''/a.001$						km/sec		
	$^\circ$		^{h}	^{m}	^{s}	$^\circ$	$'$	$''$		$^\circ$	$^\circ$	$^\circ$	$^\circ$		
1	7 493	Y 1221	3 14 45	7 28 24	8.4	F8	149	8 +15	8	150	84.3	3.0	- 2.5	45.5	
2	7 494	Y 1223	3 14 52	7 30 28	8.6	Go	168	8	0	7	168	90.0	2.4	+ 3.2	45.5
3	19 547	GC 4170	3 27 37	19 56 1	7.9	G5	161	5 -54	6	169	108.5	1.9	+ 7.8	43.0	
4	23 465	GC 4230	3 29 52	23 31 28	9.0	G5	158	7 -35	7	162	102.5	2.6	- 2.1	43.5	
5	20 598	Y 1075	3 34 39	21 10 49	9.0	G5	135	5 -48	5	143	109.6	1.8	+ 6.8	42.0	
6	16 523	GC 4677	3 50 18	17 10 47	5.96	Fo	149	2 -28	2	151	100.6	0.7	+ 0.3	37.5	
7	16 529	Y 1046	3 52 15	16 51 10	8.9	K2	159	5 -32	6	162	101.4	2.0	+ 1.3	37.0	
8	9 524	GC 4790	3 56 56	10 11 23	6.42	F2	174	10 + 9	10	174	87.0	3.3	- 4.3	35.0	
9	19 641	GC 4796	3 57 44	20 14 29	8.8	Go	148	7 -51	6	157	109.0	2.1	+ 3.6	36.5	
10	15 582	Y 1085	4 3 26	15 33 51	8.3	Go	138	5 -19	6	139	97.8	2.3	- 2.0	34.0	
11	14 657a	GC 4964	4 4 52	15 1 50	5.94	Fo	137	5 -23	4	139	99.5	1.5	+ 0.2	33.5	
12	14 657b	GC 4964	4 4 52	15 1 50	8.7	G7	138	5 -23	4	140	99.5	1.5	+ 0.2	33.5	
13	18 594	GC 5023	4 7 49	18 17 40	6.62	F8	116	5 -45	5	124	111.2	2.2	+ 6.7	33.5	
14	5 601	GC 5042	4 8 40	5 23 40	5.71	Fo	152	2 +10	2	152	86.2	0.7	+ 1.5	32.5	
15	23 649	Y 1363	4 11 32	23 27 3	8.3	G5	131	5 -42	6	138	107.8	2.3	- 4.6	34.5	
16	22 657	GC 5106	4 11 32	22 19 38	7.00	F2	94	7 -28	6	98	106.6	3.3	+ 4.3	34.0	
17	14 673	Y 1243	4 11 36	14 30 0	8.7	G5	114	8 - 5	6	114	92.5	3.0	- 6.7	32.0	
18	12 566	Y 1244	4 11 40	12 18 37	8.6	Go	111	8 - 2	6	111	91.0	3.1	- 4.7	31.5	
19	10 551	Y 1245	4 11 49	10 34 35	8.1	F5	123	6 + 9	5	123	85.8	2.2	- 7.1	31.5	
20	15 603	GC 5137	4 12 56	15 16 38	6.35	F5	121	2 -29	2	124	103.5	0.9	+ 2.8	31.5	
21	21 612	Y 1375	4 13 35	21 47 7	8.9	G5	113	5 -46	6	122	112.1	2.6	+ 1.7	33.5	
22	16 577	Y 1126	4 14 47	16 49 35	8.6	G5	121	5 -19	5	122	98.9	2.2	- 4.5	31.5	
23	17 703	Y 1129	4 15 8	18 8 9	7.8	G5	117	5 -30	6	121	104.4	2.6	- 1.0	32.0	
24	21 618	GC 5189	4 15 25	21 27 32	5.56	A5	100	2 -35	2	106	109.3	1.0	- 1.1	33.0	
25	15 609	Y 1130	4 15 28	15 58 3	9.1	K4	116	5 -23	5	118	101.3	2.4	- 0.9	31.0	
26	19 694	Y 1133	4 16 2	19 47 13	8.6	G5	118	5 -27	6	121	102.9	2.8	- 5.4	32.0	
27	17 707	Y 1134	4 16 15	17 24 17	8.8	G5	110	5 -27	5	113	103.8	2.4	- 0.6	31.5	
28	15 612	GC 5226	4 16 57	15 30 30	3.86	Ko	120	1 -24	1	122	101.3	0.4	- 0.3	31.0	
29	16 579	GC 5230	4 17 3	16 24 13	6.86	Go	121	4 -34	3	126	105.7	1.3	+ 2.7	31.0	
30	13 663	GC 5234	4 17 8	13 54 58	5.59	Fo	119	2 -20	2	120	99.5	0.9	+ 0.5	30.5	
31	18 623	Y 1139	4 17 18	19 6 54	8.1	F8	125	5 -33	6	129	104.8	2.5	- 2.7	31.5	
32	18 624	GC 5246	4 17 30	18 37 28	5.96	Fo	112	5 -44	6	120	111.5	2.7	+ 4.9	31.5	
33	14 682	GC 5252	4 17 46	14 58 38	5.27	Fo	112	2 -23	2	114	101.6	0.9	+ 0.7	30.5	
34	13 665	GC 5260	4 18 4	13 44 47	6.14	F2	116	3 -24	3	118	101.7	1.4	+ 2.9	30.0	
35	20 740	GC 5271	4 18 34	20 55 23	6.88	F8	110	6 -28	5	113	104.3	2.4	- 6.1	32.0	
36	18 629	GC 5273	4 18 38	18 18 2	6.74	F5	105	6 -27	7	109	104.5	3.5	- 2.0	31.0	
37	14 687	GC 5277	4 18 45	14 17 33	6.71	Fo	118	8 -28	8	121	103.3	3.7	+ 3.4	30.0	
38	13 668	GC 5287	4 19 14	13 57 38	5.76	A3	116	2 -24	2	118	101.7	0.9	+ 2.4	30.0	
39	16 585	GC 5300	4 19 52	16 40 30	7.8	G5	147	6 -47	5	154	107.7	1.7	+ 3.8	30.5	
40	14 690	Y 1278	4 19 54	14 56 25	8.1	Go	109	8 -26	6	112	103.5	3.0	+ 2.4	30.0	
41	17 712	GC 5304	4 20 3	17 25 37	3.93	Ko	112	1 -31	1	115	105.5	0.5	+ 0.3	30.5	
42	21 635	Y 1407	4 20 24	21 15 51	8.8	G5	99	5 -55	6	112	119.1	3.7	+ 7.6	31.5	
43	19 708	Y 1152	4 20 27	19 32 37	9.0	G7	103	5 -39	6	110	110.7	2.9	+ 2.0	31.0	
44	24 654	GC 5313	4 20 29	24 17 26	7.23	F5	94	4 -44	4	104	115.1	2.1	- 0.6	33.0	
45	16 586	GC 5315	4 20 33	16 39 44	5.68	A2	109	2 -29	2	112	104.9	1.0	+ 0.8	30.0	
46	14 691	Y 1280	4 20 42	14 33 19	8.7	G5	102	8 -25	6	105	103.8	3.2	+ 3.2	29.5	
47	17 714	GC 5328	4 21 13	17 19 47	4.84	A5	115	2 -39	1	121	108.7	0.4	+ 3.3	30.5	
48	21 641	GC 5330	4 21 16	21 37 20	8.0	F5	110	6 -58	6	124	117.7	2.7	+ 5.5	31.5	
49	16 589	Y 1159	4 21 21	16 15 53	8.5	Go	94	5 -20	6	95	102.0	3.4	- 1.5	30.0	
50	14 693	Y 1285	4 21 22	14 38 38	8.0	Go	121	8 -27	6	123	102.6	2.6	+ 1.8	29.5	

TABLE 2a (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
No	BD	Yale or GC	α_{1950}	δ_{1950}	m_v	Sp	$\mu_a \cos \delta$ p.e.	μ_δ p.e.	μ	ψ_0 p.e.	$\Delta\psi$	λ	$V_{\text{rad.}}$ p.e.	ΔV
			h m s ° ' "				unit $\sigma''/\text{a.001}$						km/sec	
51	16 591	Y 1162	4 21 30	16 57 54	7.5	F8	100 5 -34	5	105	108.8 2.5	+ 4.0	30.0	43.0 0.6	M + 4.9
52	16 592	GC 5339	4 21 36	16 46 19	8.0	Go	118 6 -31	6	122	104.7 2.6	+ 0.3	30.0	43.8 0.7	M + 5.7
53	18 633	GC 5344	4 22 2	18 55 43	5.96	Fo	110 3 -45	2	118	112.3 0.9	+ 4.2	30.5	36.1 0.4	M - 1.8
54	21 642	GC 5350	4 22 23	22 10 52	4.36	A3	101 2 -48	2	111	115.4 1.0	+ 2.1	31.5	39.8 1.2	*) + 2.3
55	21 643	GC 5351	4 22 26	22 5 14	5.42	Fo	114 2 -54	2	126	115.3 0.8	+ 2.1	31.5	31.7 1.2	*) - 5.8
56	17 719	GC 5354	4 22 36	17 48 55	4.24	A2	114 2 -29	1	117	104.3 0.5	- 2.1	30.0	35.2 0.2	*) - 2.8
57	15 621	GC 5356	4 22 46	15 49 42	6.40	F8	113 3 -28	3	116	103.9 1.4	+ 0.8	29.5	33.7 1.1	SA - 4.6
58	18 636	Y 1172	4 22 57	18 45 6	8.0	Go	134 5 -30	5	137	102.6 1.9	- 5.5	30.0	42.3 1.7	M*) + 4.2
59	15 624	GC 5367	4 23 15	15 24 44	7.43	Go	115 7 -37	8	120	107.9 3.5	+ 5.7	29.5	40.9 2.0	M + 2.7
60	22 696	GC 5370	4 23 19	22 42 7	4.40	A5	110 2 -47	1	119	113.1 0.4	- 1.2	31.5	33.3 0.4	*) - 4.2
61	4 690	Y 1625	4 23 18	5 2 15	7.9	F5	109 7 + 6	6	109	86.8 3.2	+ 3.2	29.0	31.1 0.3	W*) - 7.3
62	21 644	GC 5372	4 23 20	21 21 31	7.51	F8	102 5 -36	5	109	109.5 2.5	- 2.7	31.0	42	W*) + 4.3
63	16 598	Y 1176	4 23 32	16 44 29	8.0	Go	106 5 -19	6	107	100.2 3.0	- 4.5	29.5	40.4 2.7	W + 2.2
64	16 601	Y 1178	4 23 48	16 38 7	8.1	Go	108 5 -25	6	111	103.0 2.9	- 1.5	29.5	40.6 1.2	M + 2.4
65	15 627	Y 1184	4 24 45	15 28 43	7.9	Go	112 5 -29	6	115	104.5 2.8	+ 1.8	29.0	40.3 0.5	M + 1.9
66	11 614	Y 1299	4 24 59	11 37 34	7.5	F8	122 8 - 4	6	122	91.9 2.6	- 4.0	28.0	42.2 1.1	W + 3.4
67	21 647	GC 5412	4 25 2	21 30 37	5.74	A5	100 3 -38	3	107	110.8 1.5	- 2.1	30.5	35.9 1.4	M - 1.9
68	14 702	GC 5425	4 25 33	14 37 53	5.97	Fo	112 3 -22	3	114	101.1 1.4	- 0.4	28.5	44.7 1.1	S*) + 6.1
69	19 727	Y 1187	4 25 41	19 37 53	8.4	G5	102 5 -53	5	115	117.4 2.3	+ 7.5	30.0	36.4 0.6	W - 1.7
70	18 640	GC 5430	4 25 42	19 4 16	3.63	Ko	114 1 -38	1	119	108.4 0.4	- 0.8	29.5	38.4 0.3	*) + 0.2
71	15 631	GC 5433	4 25 43	15 51 10	4.04	Ko	107 2 -27	1	110	104.2 0.5	+ 0.6	29.0	40.5 0.6	M*) + 2.0
72	15 632	GC 5436	4 25 48	15 45 42	3.62	Fo	107 2 -25	1	110	103.1 0.5	- 0.4	28.5	41.5 4	*) + 3.0
73	16 606	Y 1191	4 25 55	17 10 35	8.2	Go	106 5 -46	6	115	113.4 2.8	+ 7.4	29.0	40.5 1.4	W + 2.1
74	12 598	GC 5443	4 26 2	12 56 18	5.12	A5	113 3 -12	2	113	96.1 0.9	- 2.3	28.0	33.0 1.7	M*) - 5.8
75	15 633	GC 5445	4 26 8	16 3 0	6.58	F8	101 5 -41	6	108	112.1 3.0	+ 8.3	29.0	45	W*) + 6.6
76	26 722	Y 2090	4 26 26	26 33 50	9.0	G5	91 11 -52	7	105	119.7 3.6	- 1.0	32.5	37.3 1.9	W + 0.4
77	17 731	Y 1193	4 26 27	17 26 11	7.3	Go	109 5 -29	6	113	104.9 2.8	- 1.6	29.0	33.2 2.4	W*) - 5.2
78	17 732	GC 5455	4 26 36	17 45 18	7.06	F8	122 9 -35	10	126	106.0 4.2	- 1.1	29.0	34.4 0.1	W*) - 4.0
79	17 734	Y 1195	4 26 38	17 47 6	9.1	G7	121 5 -35	5	125	106.1 2.1	- 1.1	29.0	44.8 0.6	W + 6.4
80	15 636	GC 5467	4 27 17	15 31 49	5.70	Fo	106 2 -24	2	108	102.8 1.0	- 0.4	28.5	31.5 1.0	*) - 7.1
81	19 731	GC 5470	4 27 22	19 44 0	7.15	F5	94 5 -39	5	101	112.5 2.6	+ 1.9	29.5	37.2 0.8	W - 1.0
82	15 637	GC 5480	4 27 42	16 5 12	4.84	A5	112 2 -27	2	115	103.5 0.9	- 0.8	28.5	36.0 0.6	*) - 2.6
83	15 639	GC 5482	4 27 48	15 35 5	5.49	A5	107 2 -23	2	109	102.1 1.0	- 1.5	28.0	39.2 0.6	M + 0.5
84	13 690	GC 5483	4 27 48	13 37 2	5.50	Fo	109 3 -21	2	111	100.9 1.0	+ 1.0	28.0	39.1 0.9	M + 0.3
85	15 640	GC 5487	4 27 55	16 2 30	6.66	F2	102 4 -42	3	110	112.4 1.2	+ 8.2	28.5	43.1 0.6	M + 4.3
86	10 588	Y 1316	4 28 11	10 38 42	8.1	F5	115 6 - 6	5	115	93.0 2.5	- 1.2	27.5	36.9 1.8	W - 2.1
87	19 733	Y 1204	4 28 19	20 1 37	8.7	G5	90 4 -33	5	95	110.2 2.8	- 1.0	29.5	40.0 1.3	W + 1.8
88	13 691	Y 1319	4 28 40	13 47 50	8.4	F8	110 7 - 6	5	110	93.1 2.6	- 7.3	27.5	42.4 0.8	W + 3.4
89	15 645	GC 5517	4 29 0	15 44 45	6.04	Fo	106 2 -27	2	109	104.3 1.0	+ 0.4	28.0	39.0 1.9	W*) + 0.2
90	5 674	GC 5531	4 29 25	5 18 15	6.43	F2	116 5 +10	4	116	85.1 1.8	+ 1.2	27.0	40.7 1.5	W + 1.7
91	15 646	Y 1210	4 29 58	15 54 4	8.9	Ko	91 5 -29	5	95	107.7 2.8	+ 3.4	28.0	43.4 0.5	W + 4.6
92	15 647	Y 1212	4 30 8	15 42 52	8.7	G5	106 5 -13	5	106	97.0 2.7	- 7.2	27.5	39.4 1.1	M + 0.6
93	16 620	Y 1217	4 30 45	16 39 31	9.0	G5	98 5 -31	6	103	107.6 3.1	+ 1.8	28.0	43.4 1.3	W + 4.6
94	12 608	GC 5556	4 30 58	13 8 54	6.66	F2	119 5 -16	5	120	97.7 2.2	- 1.6	27.0	34.4 2.3	W - 4.8
95	14 720	GC 5558	4 31 0	14 44 28	4.75	A5	105 2 -27	2	108	104.5 1.0	+ 2.1	27.5	40.1 0.6	S + 1.1
96	14 721	Y 1221	4 31 8	15 3 37	8.7	K1	113 5 -27	5	115	103.5 2.3	+ 0.6	27.5	37 1	M - 2.0
97	15 651	Y 1223	4 31 44	15 24 7	8.1	F8	110 5 -43	6	118	111.3 2.7	+ 7.5	27.5	41.2 0.6	W + 2.2
98	27 667	Y 1213	4 31 47	27 57 47	9.0	F5	79 11 -67	8	104	130.3 3.8	+ 6.3	32.5	32.3 1.3	W - 5.0
99	15 654	Y 1234	4 33 14	15 34 59	9.0	Ko	96 5 -28	6	99	106.3 3.2	+ 1.9	27.0	43.5 1.9	W + 4.3
100	23 715	GC 5611	4 33 28	23 14 26	6.04	F2	117 7 -56	7	130	115.6 2.9	- 2.4	29.5	42.5 1.3	*) + 4.4

TABLE 2a (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
No	BD	Yale or GC	α_{1950}	δ_{1950}	m_v	Sp	$\mu_a \cos \delta$ p.e.	μ_δ p.e.	μ	ψ_0 p.e.	$\Delta\psi$	λ	V_{rad} p.e.	ΔV
			h m s				unit $^{\circ}/a.001$						km/sec	
101	15 656	GC 5616	4 33 49	15 46 8	6.67	F8	103 7 -29	6	107	105.7 3.0	+ 0.9	27.0	33.2 0.6	W - 6.0
102	14 728	GC 5629	4 34 41	15 2 49	7.79	Go	98 5 -43	8	107	113.7 4.0	+10.0	26.5	39.7 1.9	W + 0.4
103	15 661	GC 5643	4 35 17	15 56 5	5.80	Fo	97 2 -23	3	99	103.4 1.6	- 2.2	26.5	38.2 1.4	M - 1.1
104	12 618	GC 5645	4 35 22	12 24 44	4.30	A3	103 3 -11	2	103	96.1 1.0	- 2.4	26.0	44.4 2.1	*) + 4.8
105	22 721	Y 1477	4 35 50	23 3 10	8.0	F5	124 5 -58	6	137	115.0 2.3	- 3.3	29.0	39.6 1.1	W + 1.2
106	13 702	Y 1346	4 36 8	14 0 29	8.1	G5	96 7 - 9	5	96	95.3 2.8	- 6.5	26.0	39.7 1.7	W + 0.2
107	7 681	GC 5665	4 36 24	7 46 24	5.55	Fo	92 4 + 2	3	92	88.8 1.8	- 0.1	25.5	39.5 1.0	*) - 0.3
108	15 666	GC 5666	4 36 25	15 49 14	4.85	A3	86 2 -17	2	88	101.2 1.2	- 4.2	26.5	37.0 1.0	*) - 2.4
109	23 722	Y 1485	4 37 5	23 12 31	9.0	Ko	80 5 -49	6	94	121.5 3.0	+ 2.8	29.0	40.0 2.0	W + 1.6
110	23 723	Y 1488	4 37 47	23 42 53	8.7	G5	70 5 -69	6	99	134.6 3.0	+14.7	29.0	32.3 1.9	W - 6.1
111	10 621	GC 5767	4 41 39	11 3 16	5.35	A3	102 2 -13	2	102	97.3 1.0	+ 0.9	24.0	39.3 0.7	M - 0.9
112	11 646	GC 5802	4 43 15	11 36 57	5.43	Ao	74 4 - 4	3	74	93.1 2.2	- 4.6	24.0	38.2 1.4	*) - 2.0
113	8 759	Y 1789	4 44 1	8 55 43	7.9	F5	101 8 + 8	7	101	85.5 3.7	- 6.2	23.5	39.8 0.4	W - 0.5
114	17 786	Y 1302	4 44 43	18 10 16	8.4	Go	94 5 -45	5	104	115.6 2.6	+ 3.4	25.0	42.0 0.7	W + 2.1
115	20 823	Y 1529	4 45 43	21 0 54	8.9	G5	87 5 -34	5	93	111.3 2.9	- 6.7	26.0	42.4 1.6	W + 2.9
116	18 736	Y 1313	4 46 8	18 33 19	8.7	F5	78 5 -36	5	86	114.8 3.1	+ 1.6	25.0	42.6 0.8	W + 2.8
117	24 692	Y 1532	4 46 9	24 43 3	9.1	K5	90 5 -71	6	115	128.2 2.8	+ 4.2	28.0	44	W*) + 5.2
118	15 686	GC 5869	4 46 40	15 48 11	7.92	F8	81 4 -26	3	85	107.8 1.9	- 0.3	24.0	39.7 2.2	W - 0.6
119	16 657	GC 5885	4 47 30	17 7 5	7.22	F8	97 6 -41	6	105	113.0 3.1	+ 2.2	24.0	41.6 0.8	W*) + 1.4
120	14 770	Y 1393	4 47 43	14 59 57	8.1	G5	103 8 -21	6	105	101.5 3.0	- 4.6	23.5	43.7 0.2	W + 3.4
121	15 692	Y 1325	4 47 56	16 7 36	7.5	F8	93 5 -27	6	96	106.2 3.3	- 2.7	23.5	41	W*) + 0.7
122	10 654	GC 5906	4 48 26	10 59 3	6.96	F5	109 8 + 8	7	109	85.8 3.4	-11.1	22.5	38.6 1.3	M*) - 2.1
123	18 743	GC 5907	4 48 27	18 45 23	5.12	Fo	83 2 -34	2	89	112.3 1.2	- 1.9	24.5	38.7 1.7	S*) - 1.2
124	13 728	GC 5923	4 49 1	13 34 20	6.70	F5	114 11 -31	8	118	105.2 3.6	+ 2.2	23.0	38.3 1.6	M*) - 2.2
125	22 769	Y 1550	4 50 37	22 56 23	8.8	Go	65 5 -34	5	73	117.5 3.2	- 5.5	26.0	45.2 1.9	W + 5.7
126	19 811	GC 5984	4 52 2	19 24 22	6.24	Fo	65 6 -38	7	74	120.2 3.7	+ 3.4	24.0	41.2 0.8	W*) + 1.0
127	13 749	Y 1431	4 54 59	13 55 34	8.7	G5	90 7 -14	5	90	98.8 3.2	- 6.4	21.5	46.4 1.1	W + 5.6
128	15 713	GC 6085	4 56 52	15 50 35	6.70	F5	92 2 -23	2	94	104.0 1.1	- 6.5	21.5	43.9 1.0	M + 3.1
129	21 751	GC 6158	5 0 6	21 31 13	4.70	A5	68 1 -42	1	79	121.7 1.4	- 2.0	23.5	42.5 1.4	*) + 2.2
130	9 743	GC 6300	5 6 35	9 46 1	5.42	A2	67 3 - 3	2	67	92.6 1.6	- 3.2	18.0	39.0 1.0	*) - 2.8
131	27 732	GC 6301	5 6 37	27 58 7	6.1	A3	62 4 -70	3	94	138.5 2.5	+ 1.4	26.5	41.3 0.9	W*) + 2.0
132		GC 6302	5 6 37	27 58 18	8.1	G7	57 9 -73	7	93	142.0 3.7	+ 4.8	26.5	46.4 0.4	W*) + 7.1

TABLE 2b

133	9 409	Y 1188	3 8 18	9 48 6	8.7	Go	159 8 - 4	8	159	91.4 2.8	+ 2.6	47.0	-	
134	4 568	Y 1065	3 37 29	4 28 10	8.9	Go	134 7 + 7	7	134	87.0 3.0	+ 3.3	40.0	-	
135	2 595	Y 1090	3 41 17	3 17 19	8.7	G5	128 7 + 29	7	131	77.2 3.0	- 5.0	39.5	-	
136	8 571	Y 1398	3 45 40	8 25 41	8.0	G5	105 8 - 15	7	106	98.1 3.7	+ 9.5	38.0	-	
137	17 666	GC 4807	3 57 56	18 3 16	5.76	Fo	137 3 - 33	2	141	103.5 0.8	+ 1.1	36.0	12.2	HII*) -23.4
138	29 676	Y 2010	4 8 30	29 42 14	8.2	Ko	142 9 -115	7	183	129.0 2.8	+ 9.4	37.5	-	
139	30 659	Y 2057	4 19 11	30 18 30	8.8	G5	103 15 - 28	9	106	105.2 4.7	-18.0	36.0	-	
140	4 686	Y 1294	4 22 4	4 35 9	8.8	G5	100 7 + 3	7	100	88.3 4.0	+ 5.5	29.0	-	
141	15 625	GC 5375	4 23 30	15 30 23	4.60	A5	116 2 - 23	2	118	101.2 1.0	- 1.0	29.0	16.6 4.3	*) -20.5
142	15 678	Y 1296	4 43 39	15 22 59	8.2	G5	98 5 - 31	6	103	107.5 3.1	+ 1.4	24.5	-	
143	15 695	Y 1327	4 48 32	15 21 0	8.0	F8	73 5 - 34	6	80	115.0 3.2	+ 8.0	23.5	-	
144	10 661	Y 1400	4 49 12	10 43 16	8.9	-	76 6 - 16	5	77	101.9 3.7	+ 5.6	22.5	-	
145	19 801	Y 1334	4 49 45	19 55 7	9.2	-	79 5 - 10	6	80	97.2 4.2	-19.5	25.0	-	
146	16 664	GC 5968	4 51 9	16 56 46	7.12	F8	81 5 - 3	4	81	92.1 2.8	-19.0	23.5	54	W*) +13.5
147	9 686	Y 1869	4 52 41	10 7 46	8.7	Go	89 5 - 14	5	90	98.9 3.0	+ 3.6	21.5	-	
148	27 712	GC 6041	4 54 33	27 18 6	8.6	F5	136 11 -141	8	196	136.1 2.8	+ 5.0	28.0	-	
149	0 905	Y 1152	4 54 48	0 54 53	8.8	G5	56 6 + 18	7	59	72.2 6.4	+ 0.2	22.0	-	
150	16 688	Y 1381	5 1 11	17 3 24	8.8	Ko	98 5 - 63	5	116	122.6 2.6	+ 7.9	21.0	-	
151	6 829	Y 1987	5 2 59	6 23 53	8.8	K2	78 7 + 9	6	78	83.4 4.4	- 2.2	19.0	-	
152	27 733	Y 2321	5 6 52	27 34 58	8.9	G5	151 20 - 66	12	164	113.7 3.6	-22.3	26.5	-	

Notes to Tables 2a and 2b.

- 6: (H II) gives rad. velocity $+36.4$, no probable error mentioned.
- 11 and 12: Form a binary; no separate proper motions known. The radial velocity of the brighter component 11 is an average of three published data: $+34.9 \pm 1.7$ (W), $+33.4 \pm 0.6$ (SA), $+35.2$ (H II). DD gives the velocity as variable.
- 13: (M) gives rad. vel. $+31$.
- 14: Variable velocity.
- 20: Velocity is average of: $+37.0 \pm 1.8$ (W), $+33.2 \pm 1.1$ (SA) and $+37.3 \pm 1.7$ (DD).
- 22: Spectroscopic binary.
- 24: (M) gives rad. vel. $+26 \pm 2$, (H II) gives $+36.6$.
- 28: Velocity is average of: $+38.5 \pm 0.3$ (M) and $+38.5 \pm 1.4$ (W).
- 29: Visual binary, $7^m.0 - 8^m.9$; $0''.4$. Observed as one; the rad. velocity probably refers to the brighter component.
- 30: Variable velocity. Velocity given is average of $+40$ (W) and $+42.0$ (S).
- 33: Velocity is average of: $+37.6 \pm 1.0$ (S), $+39.7 \pm 2.8$ (W), $+29 \pm 3$ (M) and $+32.2$ (H II).
- 37: Velocity is average of: $+38.4 \pm 0.5$ (W) and $+36.7 \pm 1.1$ (DD).
- 38: Velocity is average of: $+42.7$ (S) and $+37.7$ (W); announced variable.
- 40: Spectroscopic binary.
- 41: (H I) gives velocity $+37.4$.
- 44: (M) gives velocity $+34$.
- 45: Spectroscopic binary.
- 47: Velocity is average of: $+36.8 \pm 0.7$ (S), $+36.6 \pm 1.9$ (M), and $+37.9$ (H II).
- 54: Velocity is average of: $+41.0 \pm 1.2$ (M) and $+36.7$ (H II).
- 55: Velocity is average of: $+30 \pm 3$ (M) and $+32.4$ (H II); poor lines.
- 56: Velocity is average of: $+35.2 \pm 0.2$ (M) and $+37.5$ (H II).
- 58: Visual binary, $7^m.8 - 8^m.4$; $0''.2$. Observed as one.
- 60: Velocity is average of: $+34.6 \pm 1.5$ (S), $+33 \pm 3$ (M) and $+32.4$ (H II).
- 61: This star occurs also in the Yale Zone of $1^\circ - 5^\circ$ declination as number 1300. The proper motion given in the table is based on the average of the proper motions of the two zones.
- 62: Variable velocity.
- 68: (M) gives $+51.1 \pm 1.7$ with suspected variability.
- 70: Velocity is average of: $+38.8 \pm 0.3$ (M) and $+38.1 \pm 0.6$ (W).
- 71: Variable velocity. (H I) gives $+36.2$, $+34.8$.
- 72: Velocity is average of: $+42.6$ (M) and $+42.8$, $+51.9$, $+28.7$ (H II, three plates).
- 74: (H II) gives $+35.9$.
- 75: Variable velocity.
- 77: (M) gives $+37$.
- 78: (M) gives $+34$.
- 80: Velocity is average of: $+34.6$ (S), $+28.8 \pm 2.7$ (M), $+27$ (W) and $+26.2 \pm 1.4$ (SA). Visual binary, $5^m.9 - 9^m.0$; $1''$, velocity of the brighter component.
- 82: Velocity is average of: $+36.8 \pm 0.6$ (S), $+33.6$ (H II) and $+37.7 \pm 2.2$ (M, announces var. velocity).
- 89: Probably variable velocity. (S) gives $+38.9$, (SA) gives $+26.7 \pm 2.3$, (M) gives $+41 \pm 6$.
- 100: Velocity is average of: $+41.7 \pm 2.0$ (W) and $+43.2 \pm 1.6$ (SA).
- 104: Variable velocity. Here given average of: $+41.4$ (S), $+45$ (W), $+50 \pm 3$ (M) and $+41.3$ (H II).
- 107: Velocity is average of: $+37.0 \pm 1.8$ (S), $+42.0 \pm 1.1$ (W), $+30 \pm 4$ (M) and $+36.9$ (H II).
- 108: Velocity is average of: $+38.2 \pm 1.3$ (S), $+43.8 \pm 2.5$ (W), $+22 \pm 4$ (M, var.?), $+34.4$ and $+31.5$ (H II).
- 112: Velocity is average of: $+41.3 \pm 2.2$ (S) and $+38.8 \pm 1.5$ (M).
- 117: Variable velocity.
- 119: (M) gives $+41$.
- 121: Variable velocity.
- 122: Visual binary, $7^m.9 - 9^m$; $0''.3$; observed as one.
- 123: (M) gives $+30 \pm 3$; $+37.5$ and $+34.4$ (H II).
- 124: Visual binary, $7^m - 10^m$; $0''.5$. Velocity refers to brighter component.
- 126: (SA) gives $+31 \pm 2.8$.
- 129: Velocity is average of: $+43.6 \pm 1.4$ (M) and $+40.1$ (H II).
- 130: Velocity is average of: $+38.8 \pm 1.0$ (M) and $+39.2$ (H II).
- 131 and 132: Components of visual binary.
- 137: Numerous fuzzy lines with poor interagreement.
- 141: Velocity is average of $+3 \pm 6$ (M, 4 plates) and $+46.3$, $+41.1$ (S). M suspects variability; fuzzy lines.
- 146: Variable velocity.

direction, while to the south the density drops more rapidly. Furthermore, the part from $\alpha = 4^h 29^m$ to $4^h 44^m$, $\delta = +16^\circ$ to $+23^\circ$ is entirely empty. Rather too large irregularities are likewise encountered when the space distribution is studied. For instance, a concentration of A- and F-type stars appears in the region between 7 and 14 parsec from the centre. This apparent lack of regularity will have to be borne in mind in considering section 5, in which we will investigate the spatial distribution of the cluster stars and compare this with the distribution which would exist, should the stars in the cluster have been well mixed.

TABLE 2c

BD	GC or Yale	m_v	μ	$\Delta\psi$	ΔV km/sec
+ 29 503	GC 3554	9.2	.209	+ 3.7	- 0.9
+ 20 480	GC 3562	5.85	.237	+ 1.2	+ 0.1
+ 24 846	Y 1775	8.8	.094	+ 6.0	+ 0.6
+ 29 936	Y 2528	9.5	.080	+ 3.7	+ 6.0
+ 25 373	GC 2707	5.84	.188	+ 13.5	+ 4.5
+ 11 456	Y 975	8.4	.183	+ 2.2	+ 13.0
+ 18 514	Y 970	8.7	.146	- 9.8	+ 8.8
+ 7 592	GC 4883	5.48	.173	- 7.1	- 1.6
+ 25 674	Y 1986	9.0	.134	- 6.4	- 11.1
+ 20 721	GC 5129	8.1	.117	+ 6.4	- 9.1
- 1 697	Y 1052	8.5	.115	- 20.4	- 4.2
+ 18 719	GC 5805	6.13	.100	+ 17.9	- 0.8
+ 23 747	Y 1533	8.5	.071	+ 11.8	- 6.3
+ 17 807	Y 1341	9.2	.015	+ 38.0	- 0.1
+ 28 783	GC 6593	8.7	.071	+ 10.3	- 2.2
+ 16 822	GC 6973	5.39	.060	- 6.7	- 5.0
+ 9 1064	GC 7635	4.19	.032	+ 33.4	- 1.8

TABLE 2d

BD	Gron.	m_v
+ 23 571		9.5
+ 14 685	55	10.1
+ 13 671	81	10.1
+ 15 616	91	10.7
+ 17 715	113	10.0
+ 16 593	136	10.4
+ 17 721	152	9.1
+ 13 684	204	10.6
	205	11.4
+ 13 685		9.2
+ 14 699	212	9.7
	215	11.2
	229	10.8
+ 16 609	242	9.1
+ 15 634	238	10.5
+ 15 638	253	9.0
	283	11.0
+ 15 650	324	9.7
+ 16 630	342	11.0
+ 16 640	390	9.5
+ 19 754		9.7
+ 13 783		9.3

4. We now proceed to examine the luminosity law for the cluster stars. The survey may be considered as complete for stars brighter than +6 visual absolute magnitude. The number of cluster members per unit interval of absolute magnitude is given in Table 3.

For a determination of the total mass of the cluster it is necessary to make an assumption with regard to the number of stars fainter than absolute magnitude 6. In accordance with results obtained in photometric investigations by HOLMBERG¹⁾ and by RAMBERG (see

page 397), we suppose that the number of fainter stars per interval of one magnitude becomes approximately constant beyond $M = +5$. We thus estimate the number of K dwarfs to be 70 and the number of M dwarfs (mass 0.5 solar masses) to be 140. The total mass of the cluster then becomes about 320 solar masses, the total number of stars might be about 350.

TABLE 3

Spectrum	M_{vis}	Number of stars	Mass per star (unit is solar mass)	Mass per interval
gK	m m 0 - 1	4	4	16
B5 - A0	0 - 1	0	3	0
gK - gF	1 - 2	1	3	3
A0 - A3	1 - 2	11	2	22
A4 - A9	2 - 3	10	2	20
F0 - F2	3 - 4	26	1.4	36
F5 - F8	4 - 5	34	1.4	48
G	5 - 6	57	1.0	57
dKo - dK5	6 - 7	10	0.8	8

5. We will now investigate the spatial density distribution in the cluster. It will be assumed in the following section that the cluster has approximately spherical symmetry. As can be seen from the map in Figure 4, this assumption may not be justified. The density distribution found in the present section can therefore be only a rather crude approximation of the real distribution. In section 6 a more reliable study of the space density will be made for the stars brighter than $m = 6.5$, for which much better proper motions can be found than those given in Table 2, so that individual parallaxes can be derived. The purpose of this section is only to investigate the differences that may exist in the density distributions for stars of different spectral type, and hence of different mass. We first examine the distribution of the cluster stars as we observe it projected on the sky. The map in Figure 4 was divided into a number of strips by two sets of equidistant straight lines. The first set divided the area into strips parallel to the direction of right-ascension, with a width of 1° in declination. The second set divided the area into strips parallel to the direction of declination, with a width of 4 minutes in right-ascension. The number of stars per strip was computed. The run of the projected mass density per unit of surface with right-ascension proved to agree very well with that in declination. The centre of the cluster as found from these counts is

$$\alpha_c = 4^h 24^m \pm 1^m \text{ (m.e.)}; \delta_c = +15^\circ 45' \pm 15' \text{ (m.e.)}.$$

As the integration over the strips is not a very accurate method for determining the spatial distri-

¹⁾ *Medd. Lunds Astr. Obs. Ser. II, No. 113, 1944.*

bution, we now proceed by dividing the area of the Hyades into ring zones, drawing concentric circles round the centre. The radii of these circles are multiples of a unit corresponding to 1 parsec at the average distance of the Hyades (40.4 parsecs, see section 6).

The stars of the different spectral types were counted separately. The results are in Table 4 (columns headed: observed ¹⁾). The column K + M, and also the column "mass" is based on the estimated distribution of the fainter stars, as explained below.

Now, if the cluster is assumed to be spherically symmetrical, the relation between the projected den-

sity distribution and the space density is given by the formulae of VON ZEIPPEL ¹⁾, originally deduced for globular clusters:

$$F(r) = \frac{1}{\pi} \int_r^{\infty} \frac{\varphi'(\rho)}{\sqrt{\rho^2 - r^2}} d\rho, \quad (1)$$

or simpler for practical computations:

$$F(r) = \frac{1}{\pi} \int_r^{\infty} \sqrt{\rho^2 - r^2} \frac{d}{d\rho} \left\{ \frac{1}{\rho} \varphi'(\rho) \right\} d\rho, \quad (2)$$

TABLE 4
Projected numbers of stars of different spectral types per zone.

zone (ps)	giants		A		F		G		K + M ²⁾		mass (unit is solar mass)	
	obs	comp	obs	comp	obs	comp	obs	comp	obs	comp	obs	comp
0-1	2	1.1	0	2.6	2	4.6	4	1.3	9	9	20.2	22.7
1-2	1	1.5	3	4.7	6	9.7	9	3.2	13	13	35.2	39.9
2-3	1	0.8	3	3.8	5	9.0	11	4.1	41	41	45.6	52.1
3-4	0	0.4	1	2.5	6	7.1	5	4.5	17	17	25.6	31.3
4-5	1	0.1	1	1.5	4	5.8	3	4.8	13	13	22.4	24.1
5-6	0	0.02	1	1.0	4	4.7	3	5.0	13	13	18.4	21.6
6-7	0	0	0	0.6	2	3.7	2	4.9	12	12	12.0	18.5
7-8	0	0	2	0.3	4	2.9	5	4.6	10	10	20.6	15.4
8-9	0	0	4	0.08	6	2.1	2	4.4	10	10	24.4	13.4
9-10	0	0	0	0	1	1.5	4	4.1	10	10	11.4	13.2
10-11	0	0	0	0	8	1.1	4	3.8	10	10	21.2	11.3
11-12	0	0	0	0	1	0.6	1	3.4	9	9	7.8	9.7
12-13	0	0	0	0	0	0.4	1	3.2	9	9	6.4	9.1
13-14	0	0	1	0	4	0.2	5	2.9	8	8	17.4	8.1
14-15	0	0	0	0	0	0.05	1	2.6	7	7	5.2	6.8
15-16	0	0	0	0	0	0	1	2.3	6	6	4.6	5.9
16-17	0	0	0	0	0	0	1	2.0	5	5	4.0	5.0
17-18	0	0	0	0	0	0	0	1.7	4	4	2.4	4.1
18-19	0	0	0	0	0	0	0	1.5	3	3	1.8	2.3
19-20	0	0	0	0	0	0	1	1.1	1	1	1.6	1.7
20-21	0	0	0	0	0	0	2	0.8	0	0	2.0	0.8
21-22	0	0	0	0	0	0	0	0.5	0	0	0.0	0.5
22-23	0	0	0	0	0	0	1	0.3	0	0	1.0	0.3
23-24	0	0	0	0	0	0	1	0.09	0	0	1.0	0.09

where ρ = projected distance to centre,

r = space distance to centre,

$\varphi(\rho)$ = projected star density per unit surface, which is directly calculated from the counts,

$F(r)$ = real star density per unit of volume.

¹⁾ On close inspection the data in this and the following Tables 5 and 6 will be noticed not to be in exact agreement with those in Table 2. This is caused by the fact that the latter data have been revised according to recent results which came to our disposal after this paper was finished. The changes are very slight, however, so that it was not deemed necessary to repeat the rather laborious computations of this and the following sections. The conclusions drawn from these sections are not influenced by the change.

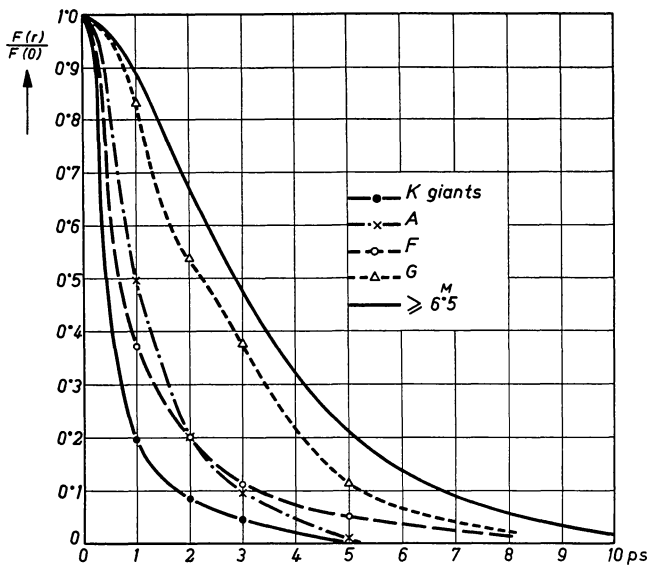
As the integration (2) yields rather inaccurate results, the computations have been repeated by using directly equation (1), as will be explained in a Note following this paper.

It must be emphasized that the number of stars per zone in our case is so small that it is impossible to use VON ZEIPPEL's formulae without smoothing the projected density distribution. A rough idea of the space distribution can, however, be obtained. The results are shown in Figure 5. For all spectral types the density in the centre of the cluster was put equal to unity.

¹⁾ *Ann. Obs. Paris XXV*, F 29, 1908.

²⁾ As the number of K + M stars is based on extrapolation, the columns *obs* and *comp* are identical.

FIGURE 5



Space-density distributions of stars of different spectral type as deduced from the projected density distributions.

The differences in the density gradient towards the centre for the different spectral types are clearly shown. Such differences one would expect if the cluster is approximately in statistical equilibrium. We have already given strong arguments that this is not so. It is of interest, however, to compare the density distributions found above with those to be expected in a statistically stable cluster.

Using the formulae applying to this case, it is possible to "predict" the distribution of the stars fainter than $M = 6$ (the K and M dwarfs). It is shown in the figure by the upper full-drawn curve. The numbers in the columns headed "K + M" and "mass" of Table 4 are based on this distribution in combination with the assumption concerning the luminosity function that was proposed in section 4. In as much as the contribution of these faint stars to the total density is not so very important, the uncertainty they introduce in the following discussion is not serious. A check may be obtained by comparing the number of faint cluster stars in the central Hyades region as found by RAMBERG¹⁾, with our numbers. In an area of 200' diameter, i.e. nearly equal to the region inside the 2 ps zone, he finds 17 cluster members between 9^m.5 and 13^m.5 pg. From the extrapolation made above we obtain 22 K + M stars in the same area.

Now we can compute the distributions for the brighter stars as they should be in a stable cluster. Starting from the projected distribution of mass as given in Table 4 we compute the space density. From this we derive the potential and the velocity of escape

TABLE 5

r (ps)	$F(r)$ (solar mass per ps ³)	$M(r)$ (solar mass)	$\Phi(r)$ (cm ² .sec ⁻²)	V_e (km.sec ⁻¹)
0	0.70	0	2.96×10^9	0.79
1	0.57	2.8	2.82	0.77
2	0.44	16	2.68	0.73
3	0.26	43	2.40	0.69
5	0.11	108	1.98	0.63
7	0.051	177	1.62	0.57
10	0.015	253	1.25	0.50
13	0.0035	288	0.97	0.44
17	0.0002	305	0.76	0.39
20	<0.0001	315	0.65	0.36
∞	0.0000	320	0.00	0.00

as a function of the distance from the centre. The results are given in Table 5.

The respective columns give: the distance from the centre, the density, the total mass contained in a sphere of radius r , the potential and the velocity of escape.

The radius of the sphere containing half of the mass of the cluster is found to be about 6 ps.

Supposing the cluster to be in *dynamical equilibrium*, and the distribution function of the internal velocities to be Maxwellian, with a root mean square internal velocity in one co-ordinate equal to $1/h \sqrt{2}$, expressed in proper units, the following relation holds between the density per unit of volume and the potential:

$$F(r) = F(0) e^{-2h^2[\Phi(0) - \Phi(r)]}. \quad (3)$$

We have to consider, however, the influence of the velocity of escape, which will cut off of the isothermal velocity distribution in the neighbourhood of this velocity. Corrections have been applied corresponding to a cut-off at V_e and at $3/4 V_e$ ¹⁾. In the latter case we take into account that in reality already for velocities considerably below the escaping limit the frequency will be less than that given by Maxwell's law.

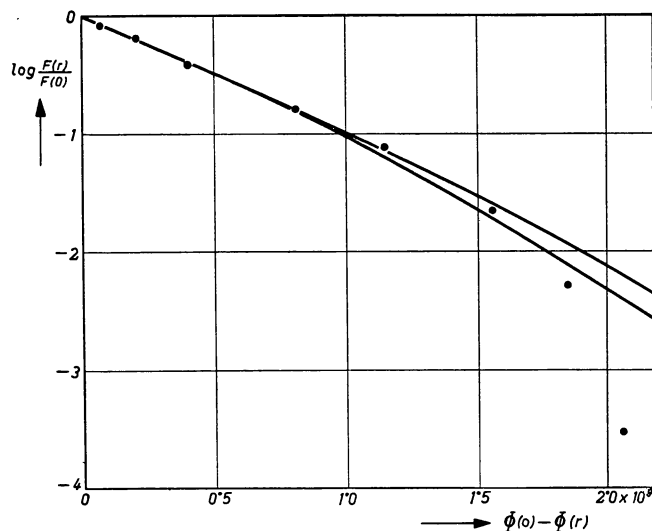
In Figure 6 $\log [F(r)/F(0)]$ has been plotted against $[\Phi(0) - \Phi(r)]$. As the correction becomes appreciable only for $[\Phi(0) - \Phi(r)] \geq 5.10^8$, the larger values of $\log [F(r)/F(0)]$ should lie on a straight line. That is indeed the case, the slope of the line being -0.98×10^{-9} . This gives $2h^2 \cdot \text{Mod} = 0.98 \times 10^{-9}$ and $h = 3.36 \times 10^{-5}$, corresponding with a root mean square internal velocity in one co-ordinate of 0.23 km.sec⁻¹, or $7^{a.0013}$.

With this value of h the correction factors were computed. The resulting theoretical density distri-

¹⁾ Compare for the computation of these corrections the chapter on globular clusters in CHANDRASEKHAR's book *Principles of Stellar Dynamics*.

¹⁾ *Stockholms Obs. Ann.* 13, No. 9, 1941.

FIGURE 6



Graph showing the logarithm of the density plotted as a function of the potential in the cluster. The upper curve gives the relation for a cluster in equilibrium, the velocity distribution being cut off at the velocity of escape; the lower curve corresponds to a cut-off at $3/4$ of this velocity.

bution may be compared with the observed distribution of mass. Table 6 and Figure 6 give the results. In the figure the two curves show the computed mass-density distribution. The dots are the observed values. It may be noticed that strictly speaking the distribution of mass in the cluster will not follow formula (3) with constant h ; stars of different mass will have different velocity distributions, and will therefore be also differently distributed in space. In the total mass distribution we observe the superposition of all these individual distributions. The upper curve has been computed by taking the total velocity of escape as limit, the lower curve by taking $3/4$ th of this value.

In the outer region of the cluster, $r > 10$ ps, the observed density is systematically too low. However, in these outer layers the number of stars is very small, and the density distribution depends almost entirely on the assumed number of unobserved faint stars. It is impossible to improve the agreement between the observed and the computed values by changing the value of h , as in that case the observations in the region from 2 to 10 ps from the centre, which are the most reliable ones, deviate systematically. The effect of taking three quarters of the velocity of escape as correction limit proves to be very small.

As a rough check on the result for h we have also computed this from the approximate relation between the radius of a cluster, its total mass and the mean internal velocity ¹⁾.

¹⁾ Cf. S. CHANDRASEKHAR, *Principles of Stellar Dynamics*, p. 200 a.f.

TABLE 6

Comparison between observed and computed density distribution.

r (ps)	$\log \frac{F(r)}{F(0)}$ observed	$\log \frac{F(r)}{F(0)}$ computed 1st corr.	$\log \frac{F(r)}{F(0)}$ computed 2nd corr.
0	0	0	0
1	-0.089	-0.061	-0.063
2	-0.201	-0.198	-0.206
3	-0.430	-0.401	-0.425
5	-0.804	-0.811	-0.848
7	-1.137	-1.180	-1.242
10	-1.669	-1.591	-1.697
13	-2.301	-1.958	-2.104
17	-3.544	-2.198	-2.381
20	$-\infty$	-2.370	-2.564

With $R = 6$ ps, $M = 320$ solar masses, we find 0.21 km.sec⁻¹ for the root mean square velocity in one co-ordinate, which agrees well enough with the value deduced above.

From CHANDRASEKHAR's expressions we can also obtain the approximate time of relaxation. This is found to be 1.1×10^8 years. The average period of revolution of a star in the cluster is about 2×10^8 years.

As these times are much shorter than the presumable age of the galactic system, it might perhaps have been expected that the statistical equilibrium in the cluster would have been fully established. We have already mentioned that the striking irregularities in the shape of the cluster point to the opposite conclusion. It is therefore plausible that the age of the Hyades cluster is less than 2×10^8 years.

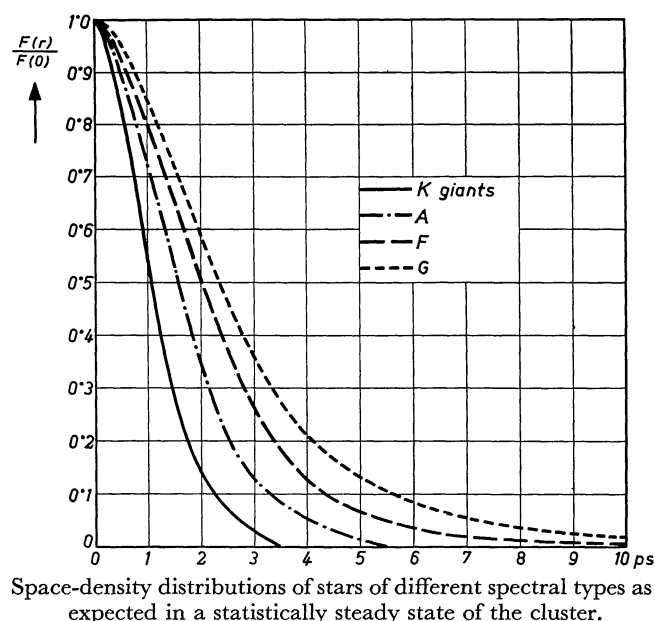
To investigate the matter further, we now compute the theoretical density distributions of the stars of different mass. Assuming equipartition of energy the velocity modulus h for stars of given mass is proportional to the square root of this mass. The calculations of the preceding section correspond to the average mass of all stars of the cluster. This average mass is about 0.92 times the mass of the sun. Expressed in this value as a unit, the following masses and values of h were adopted:

TABLE 7

type	mass expressed in average mass	h
K giants	4.3	6.99×10^{-5}
A	2.2	4.97
F	1.5	4.13
G	1.1	3.53

Theoretical density curves, assuming unit density at the centre, have now been computed for the four spectral types. They are shown in Figure 7. Correction factors were applied corresponding to a cut-off at V_c . Figures 5 and 7 are directly comparable. Qualitatively, the agreement is reasonable. The density distribution assumed for the faint stars is very important. It may be emphasized here that measurements of proper motions of faint stars in a large region round the Hyades are greatly needed.

FIGURE 7



A quantitative comparison of the observed and the theoretical density distribution can be made going back to the original star counts. The computed space densities were therefore converted into projected density distributions. The columns headed "computed" in Table 4 show the results. It is seen that the agreement is not very good, as could be expected for the reasons given above.

As a last check we computed the mean radii of the cluster (defined as the radii of the spheres which contain half of the stars concerned) for stars of different spectral type, for the observed as well as for the theoretical case. The results are given in Table 8.

From this section we may conclude that, although in some aspects it seems that the Hyades cluster has properties resembling those of a statistically stable cluster, the general shape of the cluster makes it very difficult to believe that this stable state is indeed obtained.

6. In order to check the inference drawn from the counts, and in the hope of deriving improved space densities, a new independent determination of these

densities was made by the aid of the individual parallaxes of the Hyades stars brighter than $6^m.5$, and for which the probable error of the GC proper motion is less than $''0.040$ per annum. Those stars have been indicated in Table 2a by printing their numbers in italics.

Dr H. R. MORGAN very kindly communicated to us new proper motions for these stars, as computed from his so-called N30 system. These motions have about the same accuracy as the GC motions, and are inde-

TABLE 8

Mean radius in parsecs of the cluster for stars of different spectral type.

type	obs.	theoretical
K giants	2.0	1.5
A	2.9	2.4
F	6.1	5.5
G	6.5	7.2

pendent of these. For the majority of the stars a third value of the proper motion has been given in the *New Washington Zodiacal Catalogue* 1950. These, however, are not independent of the other two determinations. In Table 9, columns (4) to (7), are given the differences between the proper motions as given in the GC (after correcting them by $\Delta\mu_\alpha = -s/a.0002$, $\Delta\mu_\delta = +s/a.002$) and MORGAN's N30 proper motions, and the Zodiacal Catalogue proper motions, resp. In order to obtain average proper motions we took weighted means of 1) the GC proper motions corrected for change of fundamental system and of the precession constants, 2) the N30 proper motions corrected for change of the precession constants and 3) the Zodiacal Catalogue proper motions also corrected in this way. These weighted means with their probable errors are given in columns (8) to (12) of the table. They are considerably more accurate than the GC proper motions. Column (13) shows the position angles corresponding to these average motions; the differences with the predicted values are entered in column (15). From the total proper motions and the cluster velocity as found previously individual distances and absolute magnitudes (Harvard visual) were derived (columns (17) and (18)). From the distances the average distance of the cluster was found to be $R_c = 40.4$ ps ± 1.1 , corresponding with an average distance modulus of $3^m.03$.

The uncertainty in the distance is largely caused by the distance scattering in the cluster, by the uncertainty in the position of the vertex and for a smaller part by the uncertainty in the velocity. The value found here may be compared with those found by

TABLE 9

(1) No	(2) GC	(3) Sp	(4) $\Delta\mu_{\alpha}\cos\delta$ N30—GC	(5) $\Delta\mu_{\delta}$ GC—GC	(6) $\Delta\mu_{\alpha}\cos\delta$ ZC—GC	(7) $\Delta\mu_{\delta}$ GC—GC	(8) $\mu_{\alpha}\cos\delta$	(9) p.e.	(10) μ_{δ}	(11) p.e.	(12) μ	(13) ψ_0	(14) p.e.	(15) $\Delta\psi$	(16) λ	(17) R	(18) M_v	(19) $-\xi$	(20) η	(21) $-\zeta$	(22) r
			unit $\sigma''/a_{\odot 001}$			unit $\sigma''/a_{\odot 001}$			unit $\sigma''/a_{\odot 001}$			$^{\circ}$			$^{\circ}$			parsecs			
6	4677	Fo	-1	+3	-9	-2	1467	10	-293	10	1496	101.3	0.35	+1.0	37 22	37.84	3.07	26.7	21.2	16.2	6.8
14	5042	Fo	-7	+8	-	-	1490	16	+130	16	1496	85.0	0.56	+0.5	32 16	32.14	3.17	25.3	11.8	15.9	11.4
20	5137	F5	-4	+6	-4	+	1190	12	-277	9	1222	103.1	0.39	+2.2	31 41	39.91	3.35	30.8	20.1	15.4	2.8
24	5189	A5	-1	+6	-3	-2	990	15	-360	12	1054	110.0	0.60	-0.7	32 47	47.43	2.18	35.6	27.4	14.8	8.0
28	5226	Ko	-1	+3	0	+1	1211	5	-240	4	1235	101.2	0.17	-0.4	30 45	38.94	0.91	30.4	19.4	14.5	2.7
30	5234	Fo	+1	-2	+3	+1	1209	15	-222	12	1229	100.4	0.51	+1.4	30 25	37.84	2.70	29.9	18.1	14.7	3.7
33	5252	Fo	-6	+5	-3	+5	1097	12	-207	12	1116	100.7	0.57	-0.2	30 29	42.05	2.15	33.1	20.6	15.7	2.5
34	5260	F2	-4	+9	-4	+8	1140	19	-193	18	1156	99.6	0.82	+0.8	30 13	40.33	3.11	31.8	19.2	15.5	2.5
38	5287	A3	+9	+2	+9	+3	1226	20	-243	19	1250	101.2	0.80	+1.9	29 58	37.02	2.92	29.2	17.5	14.1	4.4
41	5304	Ko	-3	+4	-4	+3	1106	6	-303	5	1147	105.3	0.23	+0.1	30 33	41.06	0.87	32.1	21.4	14.1	1.6
45	5315	A2	-1	+6	-1	+1	1084	15	-280	12	1120	104.5	0.56	+0.4	30 12	41.56	2.58	32.6	21.3	14.5	1.7
47	5328	A5	0	+5	+1	-2	1160	10	-397	8	1226	108.9	0.34	+3.8	30 12	38.32	1.92	30.1	19.8	13.0	2.6
53	5344	Fo	-1	+11	-3	+6	1090	19	-406	15	1163	110.5	0.68	+2.4	30 27	40.43	2.92	31.5	21.8	13.0	2.1
54	5350	A3	-1	+2	-8	+2	987	12	-480	9	1097	115.9	0.43	+2.6	31 33	44.14	1.14	33.7	25.6	12.5	5.7
55	5351	Fo	-6	+7	-10	+4	1096	15	-517	12	1212	115.3	0.52	+2.1	31 31	39.88	2.42	30.6	23.0	11.5	4.0
56	5354	A2	-1	-8	0	+5	1133	10	-306	10	1173	105.1	0.44	-1.1	30 1	39.29	1.27	30.9	20.6	13.0	1.9
57	5356	F8	-4	+10	-3	+12	1097	19	-227	17	1121	101.7	0.79	-1.4	29 29	40.14	3.37	31.9	19.9	14.1	1.1
60	5370	A5	+3	+3	0	+1	1112	15	-470	9	1207	112.9	0.39	-1.4	31 34	40.12	1.38	30.7	23.4	11.1	4.4
67	5412	A5	+8	+5	-4	-4	1023	22	-397	19	1097	111.2	0.91	-1.7	30 42	43.06	2.57	33.2	24.4	12.1	4.5
68	5425	Fo	-4	+1	-6	-2	1097	15	-243	14	1124	102.5	1.15	+1.0	28 35	37.76	3.09	30.5	21.6	11.3	3.3
70	5430	Ko	-4	+1	-4	+4	1121	4	-377	4	1183	108.6	0.18	+0.1	29 42	39.58	0.65	31.0	21.1	12.2	2.3
71	5433	Ko	0	+3	+3	+1	1087	12	-276	7	1121	104.2	0.33	+0.6	28 46	39.65	1.05	31.9	19.5	13.6	1.0
72	5436	Fo	+3	+3	+6	+4	1107	12	-247	8	1134	102.6	0.37	-0.9	28 45	39.28	0.65	31.5	19.2	13.5	1.5
74	5443	A5	-12	-2	-	-	1080	20	-145	22	1090	97.6	1.06	-0.8	28 10	40.20	2.10	32.6	18.1	14.9	2.6
80	5467	Fo	-7	-17	+1	+3	1048	10	-309	10	1093	106.4	0.48	+3.2	28 21	40.80	2.64	32.7	19.6	13.8	0.7
82	5480	A5	-7	+1	0	+1	1100	15	-283	10	1136	104.4	0.47	+0.1	28 24	39.19	1.88	31.5	19.2	13.0	1.5
83	5482	A5	-4	+5	-6	+2	1047	12	-227	12	1071	102.2	0.59	-1.2	28 15	41.03	2.43	33.1	19.9	13.9	0.7
84	5483	Fo	-2	-2	-2	+6	1090	23	-217	19	1111	101.3	0.90	+1.4	27 51	38.91	2.54	31.8	17.7	13.9	2.6
89	5517	Fo	-6	-2	-4	0	1033	12	-297	12	1075	106.0	0.59	+2.1	28 1	40.65	3.00	32.8	19.7	13.6	0.5
95	5558	A5	-4	+2	-4	+5	1014	10	-267	12	1048	104.7	0.59	+2.3	27 20	39.96	1.75	32.7	18.6	13.4	1.5
103	5643	Fo	-6	-4	-4	+1	948	15	-258	19	983	105.2	1.02	-0.4	26 36	42.04	2.68	34.7	20.0	13.0	2.0
104	5645	A3	-1	-3	-	-	1017	18	-140	16	1027	97.8	0.83	-0.7	25 50	39.78	1.30	33.3	17.0	13.7	3.2
107	5665	Fo	+6	+4	-	-	955	20	+30	30	955	88.2	1.65	-0.7	25 17	41.29	2.47	35.1	14.8	16.0	6.4
108	5666	A3	-1	-5	+2	-1	859	10	-210	15	884	103.7	0.86	-1.8	26 17	44.59	1.61	36.8	21.1	13.7	4.2
111	5767	A3	-1	+1	-	-	1020	23	-140	16	1030	97.8	0.82	+1.4	24 8	36.58	2.53	31.8	14.5	12.3	5.7
112	5802	Ao	0	-1	-	-	750	26	-60	29	753	94.6	2.05	+0.3	23 49	50.35	1.93	42.9	20.3	16.4	10.7
123	5907	Fo	-1	0	+4	-2	838	9	-367	10	915	113.6	0.58	-0.6	24 37	42.27	1.99	35.4	20.8	10.1	4.2
129	6158	A5	-1	+1	-3	+5	678	7	-420	6	797	121.8	0.40	-2.2	23 31	46.11	1.38	38.9	23.4	7.9	8.9
130	6300	A2	-11	0	-	-	625	22	-40	21	627	93.7	1.77	-2.1	17 55	45.83	2.12	41.4	15.3	12.2	10.0
131	6301	A3	-3	+9	+3	-2	635	21	-683	17	932	137.1	1.69	+0.4	26 36	43.78	2.89	35.5	25.3	4.0	11.0

other authors: SMART (*l.c.*) obtained 35.5 ps, J. J. RAIMOND JR.¹⁾ gave values between 34.5 and 38.5 ps.

Recently O. J. EGGEN²⁾ cited in his paper on the colour-magnitude diagram of the Hyades the value 40.6 ps, determined by R. E. WILSON (unpublished). For the co-ordinates of the vertex the same source mentions $\alpha_V = 6^h 16^m$; $\delta_V = +7^\circ.6$. These values are in good agreement with those found in this paper; the differences between them and the older values may be attributed to a systematic regression error, as pointed out by SEARES³⁾. This error has been avoided in our work by computing the vertex by a differential method.

From R_c and the individual parallaxes the distances r from the centre of the cluster were computed. These are in column (22). The average value of the proper motion is about $^{\circ}/a.125$, the average mean error is $\pm ^{\circ}/a.002$, or roughly 2% of this value. The mean radius of the cluster for the brighter stars is about 4 ps, or 10% of the distance from the cluster to the sun. The effect of accidental errors in the proper motion is therefore small compared to that of the real dispersion of the distances. The effect of the internal motions is quite negligible. Hence, the distance distribution as derived from the proper motions should be rather reliable.

Table 9 contains all giants and A stars, and about one third of all F stars. The observed numbers in the different distance shells around the centre may again be compared to the numbers expected according to theory. On the whole the agreement is no better than in the case of the projected distributions.

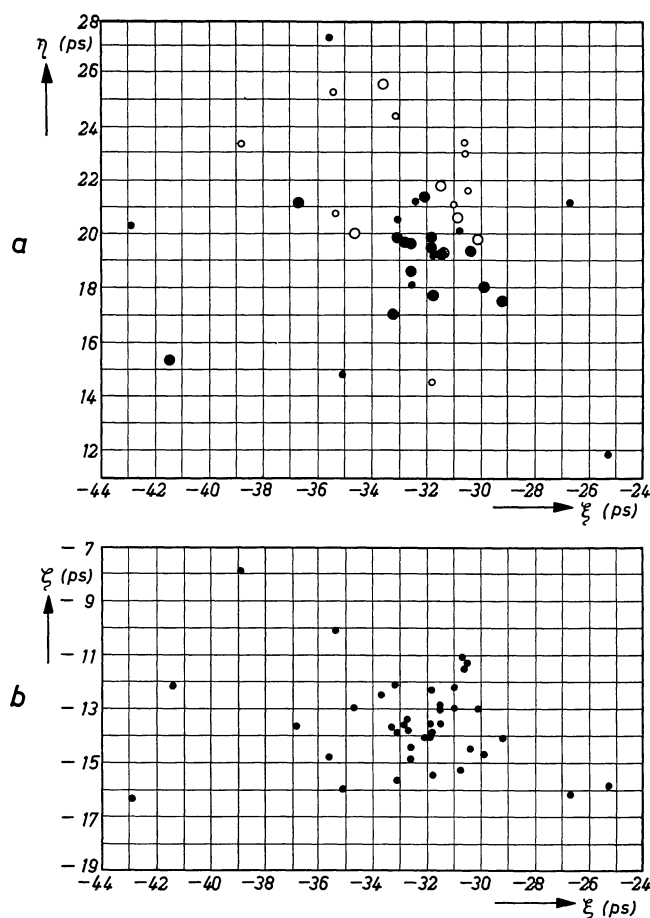
In columns (19) to (21) the rectangular co-ordinates of the stars in a co-ordinate system with the sun at the origin and axes directed along the principal axes of the galactic system (ξ in the direction of $l = 0^\circ$, ζ perpendicular to the galactic plane) are given. From these the distribution in space of the stars of Table 9 is found. It is shown in Figures 8a and b. The plane of drawing in Figure 8a is the plane through the centre of the cluster parallel to the galactic plane. The distance of the stars from this plane is indicated by the diameter of the dots and circles (black dots refer to stars below the plane of drawing, open circles to stars above that plane). In Figure 8b the space distribution is projected on a plane in the direction $l = 0^\circ$ through the centre of the cluster and perpendicular to the galactic plane. It is seen from these diagrams that the cluster has a flattened shape; the direction of flattening is roughly perpendicular to the galactic plane. Something of this kind is also slightly indicated in Figure 4. Computation gives for the galactic co-ordinates of the pole of the equatorial plane of the cluster

¹⁾ B.A.N. 3, 221, 1926.

²⁾ Ap.J. 111, 65, 1950.

³⁾ Ap.J. 102, 366, 1945 and Mt Wilson Contr. No 716.

FIGURE 8



a. Plot of the space distribution of the cluster members brighter than $6^m.5$ visual. Plane of drawing is the plane through the centre of the cluster parallel to the galactic plane. Large open circles refer to stars more than 1.0 ps above the plane of drawing, small open circles to stars between 0 and 1.0 ps above this plane, small black dots to stars between 0 and 1.0 ps below this plane and large black dots to stars more than 1.0 ps below the plane. b. Space distribution of the same stars projected on a plane through the centre containing the direction $l = 0^\circ$ and perpendicular to the galactic plane. Star 131 is not included in diagram b, as it falls outside its limits.

$l_p = 242^\circ$, $b_p = +70^\circ$. A measure of the flattening can be obtained by computing the distance dispersion (root mean square of the distance from the co-ordinate axes) in a direction in the "equatorial" plane which may be chosen arbitrarily, as there is no conclusive evidence of ellipticity in this plane, and in a direction perpendicular to it. The results are 3.3 ps and 2.2 ps, resp.; the amount of flattening therefore is 67%. About the cause of the ellipsoidal form (which was already mentioned by RASMUSON¹⁾) nothing can be said at present.

The possibility of a systematic motion of the stars in the outer region of the cluster has been investigated. No indication of such a motion was found.

¹⁾ N. H. RASMUSON, *Medd. Lunds Astr. Obs. Serie II*, No 26, 1921.

7. Proper motions of the stars down to the twelfth photographic magnitude in the central region of the Hyades have been measured and discussed by VAN RHIJN and KLEIN WASSINK in 1924 (*l.c.*).

In Tables 6, 7 and 8 of their publication proper motions are given of 68 stars, assigned as certain, probable or doubtful members of the cluster. The authors deduced a remarkably large value of the mean internal motion of the cluster stars. Denoting the root mean square internal motion in one co-ordinate by v and the average mean error for one component by ϵ , their measures seem to indicate $v = ^{\circ}.007$ and $\epsilon = ^{\circ}.0034$. Comparison of the value of v with that found from the dynamical considerations in section 5, viz. $^{\circ}.0013$, reveals a serious discrepancy. In order to check the value of v as found by the Groningen authors, we computed the root mean square residual position angle of all stars in our Table 9. This was found to be $1^{\circ}.53$. From this value we find $\sqrt{v^2 + \epsilon^2} = .0030$. The average mean error of the mean proper motions in Table 9 being about $^{\circ}.0020$, we find $v = ^{\circ}.0022$. This result is not incompatible with the theoretical value quoted above, as the errors may easily have been underestimated. One cause for such underestimate is the fact that in computing the probable errors the three catalogues were assumed to be independent; the Zodiacal Catalogue, however, is certainly not independent of the GC.

The large value of v as found from the Groningen proper motions may be caused by the presence of undetected errors in these motions. In order to investigate this possibility those stars in the list of VAN RHIJN and KLEIN WASSINK which also occur in Table 2 of the present paper were tabulated, and the Groningen proper motions were compared with those

given in the Yale catalogues, corrected in the way described above. After elimination of systematic differences the following root mean square residuals were found:

$$\begin{aligned} \text{in } \mu_{\alpha} \cos \delta &: ^{\circ}.0136, \\ \text{in } \mu_{\delta} &: ^{\circ}.0150. \end{aligned} \quad (4)$$

For the same stars (33 in number) residual position angles were computed, using the Groningen proper motions as well as the Yale proper motions. From these residuals the following values of $\sqrt{v^2 + \epsilon^2}$ were derived:

$$\begin{aligned} \text{for the Groningen proper motions: } &^{\circ}.0110 \\ \text{,, ,, Yale } &^{\circ}.0101 \end{aligned} \quad (5)$$

From (4) and (5) we conclude:

1. v must be small in comparison to the accidental errors in both catalogues. Its value cannot be larger than, say, $^{\circ}.005$.

2. The real mean errors of the proper motions in both catalogues must be about $^{\circ}.010$.

At the end of this paper I want to express my thanks to Professor OORT for the suggestion of this study and for his help and constant encouragement, to Dr H. R. MORGAN for his kindness in communicating to us his unpublished proper motions, to Dr BLAAUW for his invaluable help and advice and to Mr DE ROOY who aided much with the computations, checked the data in Tables 2 and 9, and who prepared most of the diagrams. I am indebted to Dr OOSTERHUIS and the management of the Philips Research Laboratories for allowing me time to finish the paper and for help in the preparation of the manuscript for the printers.