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THE HYADES AND COMA BERENICES STAR CLUSTERS*

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ABSTRACT

Three-color photoelectric observations, on the *U*, *B*, *V* system, are given of members of the Hyades and Coma Berenices star clusters. A number of stars which may be subdwarf members of the Hyades cluster are identified. However, if these stars are cluster members, they occur in the outer regions of the cluster A probably significant difference in the intensity of the ultraviolet radiation of the F- and G-type main-sequence stars in the Coma Berenices and Hyades clusters has been found. The main sequences of the Hyades and Praesepe clusters are nearly identical in shape The Hyades main sequence agrees well in absolute magnitude with the near-by stars. Comparison of the Hyades-Praesepe main sequence with the Pleiades main sequence reveals a systematic difference in the direction and approximate size predicted by an evolutionary theory based on the generalized Cowling model

I. THE HYADES

During the months of December, 1954, and January, February, and March, 1955, three-color observations were made on most of the known members of the Hyades cluster. The observations were made with the same filters and 1P21 photomultiplier that were used for the original definition of the *U*, *B*, *V* system (Johnson and Morgan 1953), and the observations reported here are on that system. The cluster observations were made in the manner described for Praesepe (Johnson 1952), using the two stars Nos. 71 (θ^1 Tau) and 72 (θ^2 Tau) as cluster standards. Special observations to tie the cluster observations into the fundamental system were made on fourteen different nights; in addition, many observations were made on ϵ Tau (No. 70) and η Tau, for which standard values have been given by Johnson and Harris (1954) and Johnson and Morgan (1953). These observations of ϵ Tau and η Tau provide an additional check of the cluster zero points. The estimated probable errors of the zero points are listed in Table 1*a*. The internal probable errors, relative to the two cluster standard stars, are listed in Table 1*b*. The observations on the cluster stars are listed in Table 2, which is divided into the same four groups as those used by van Bueren (1952) in his Table 2. It is therefore not necessary to list again the data he has compiled for these stars, since direct cross-reference between the two tables can be made.

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The data given in Table 2 are plotted in Figure 1, where the large spots designate the stars listed in Table 2*a* and the first four stars in Table 2*c;* the open circles, those in Table 2*b* and the rest of Table 2*c;* and the small spots, the stars in Table 2*d*. The crosses designate known binaries. The probability of cluster membership for the stars in the three groups may be judged from the following: *large spots*· both radial velocities and proper motions are in excellent agreement with those expected for cluster members; *open circles:* proper motions in excellent agreement with those expected, but no radial velocity available, or membership doubtful because of relatively large deviations from expected values of radial velocity and proper motion; *small spots:* fainter stars whose proper motions indicate cluster membership. Stars Nos. 136, 150, and 164 can be classified as nonmembers on the basis of the photometry.

The line fitting the Hyades main sequence was derived in the following manner: the best smooth curve was drawn by eye through the Hyades main sequence. The values so obtained are listed in Table 3, second column. Next, the same procedure was carried out

TABLE 1*a*

PROBABLE ERRORS (MAG.) OF TIE-IN OF HYADES STANDARDS WITH *U*, *B*, *V* SYSTEM

V	*B−V*	*U−B*
±0 008	±0 004	±0 008

TABLE 1*b*

PROBABLE ERRORS (MAG) OF HYADES OBSERVATIONS WITH RESPECT TO CLUSTER STANDARDS FOR ONE OBSERVATION

V	*B−V*	*U−B*
±0 006	±0 005	±0 010 $V<9$ 5
±0 011	±0 017	±0 025 $V>9$ 5

for Praesepe (Johnson 1952); the values for Praesepe are listed in the third column of Table 3. Praesepe was chosen as a comparison cluster because of the evident similarity of its color-magnitude diagram to that of the Hyades. The differences, Praesepe *minus* Hyades, are given in the fourth column of Table 3. It is evident that the shapes of the two main sequences are very similar and that the mean line drawn in Figure 1 is a very good fit to the Hyades observations, except possibly at the very faint end, where there are only a few stars known to be members of the Hyades cluster.

The relationship between $U-B$ and $B-V$ for the Hyades is shown in Figure 2. In this figure the crosses designate the four yellow giants, and the open circles the seventeen stars that fall considerably below the main sequence of Figure 1. One notes a significant systematic deviation of the "subdwarfs" from the main-sequence stars in the sense that the lower-luminosity stars have stronger ultraviolet. This is the same effect noticed earlier for a few near-by stars (Johnson and Morgan 1953) and clearly evident for the subdwarf HR 4550 (Johnson and Harris 1954). Miss Roman (1954) has also found this ultraviolet "excess" in a few high *Z*-velocity subdwarfs. This luminosity effect also is in the direction that would be expected from the observations in NGC 752 (Johnson 1953), in which a clear correlation between ultraviolet intensity and luminosity was found for stars on and above the main sequence.

The numbers of these "subdwarfs" are listed in Table 4. Four of these stars—Nos. 98, 125, 155, and 156—have accurately measured proper motions and radial velocities in excellent agreement with those to be expected for cluster members. Eight more—Nos. 113, 134, 139, 144, 147, 148, 172, and 188—have accurately measured proper motions (but no radial-velocity measures) that, again, agree well with those to be expected for cluster members. Furthermore, in Figure 1, most of the "subdwarfs" fall on a fairly well-defined sequence that runs approximately parallel with, and shows about the same scatter as, the cluster main sequence.

TABLE 2a

Magnitudes and Colors of Hyades Stars

Star No.	V	B-V	U-B	n
1	7.40	.566	.118	4
2	7.78	.617	.159	4
3	8.35	.751	.325	4
4	8.88	.848	.537	3
5	9.36	.920	.699	4
6	5.97	.341	.001	3
7	8.98	.896	.627	3
8	6.37	.419	-.004	4
9	8.67	.708	.235	3
10	7.85	.589	.100	3
11 +12	6.01	.396	.024	3
13	6.62	.420	-.010	3
14	5.73	.355	-.004	3
15	8.09	.658	.204	3
16	7.06	.419	.011	3
17	8.46	.696	.243	3
18	8.06	.638	.167	3
19	7.14	.512	.045	3
20	6.32	.399	.016	2
21	9.15	.816	.467	4
22	8.34	.771	.333	2
23	7.54	.679	.239	2
24	5.65	.275	.076	3
25	9.60	.987	.807	2
26	8.63	.743	.332	2
27	8.46	.715	.305	2
28	3.66	.993	.813	2
29	6.88	.561	.088	2
30	5.59	.278	.083	2
31	7.47	.566	.079	2
32	6.11	.374	.026	2
33	5.26	.223	.099	2
34	6.17	.457	.021	2
35	6.80	.436	-.010	4
36	6.80	.441	-.001	2
37	6.61	.405	.000	2
38	5.72	.320	.102	2
39	7.86	.678	.220	2
40	6.99	.563	.089	2
41	3.77	.977	.817	2
42	8.86	.759	.351	2
43	9.40	.907	.609	2
44	7.19	.450	.027	2
45	5.64	.296	.135	2
46	9.11	.867	.541	2
47	4.80	.158	.121	2
48	7.14	.521	.042	5
49	8.24	.585	.124	2
50	7.62	.601	.123	2
51	6.97	.443	.003	2
52	7.80	.597	.133	2
53	5.97	.367	.047	2
54	4.22	.137	.120	4
55	5.28	.247	.095	4
56	4.30	.049	.055	2
57	6.46	.491	.015	2
58	7.53	.680	.240	2
59	7.49	.543	.077	2
60	4.29	.268	.125	4
61	7.38	.514	.019	3
62	7.38	.537	.076	3
63	8.06	.632	.169	2
64	8.12	.657	.202	2
65	7.42	.535	.060	3
66	7.51	.555	.052	2
67	5.72	.271	.100	3
68	5.90	.320	.057	3
69	8.64	.746	.335	2
70	3.52	1.011	.878	13
71	3.85	.955	.741	std
72	3.41	.179	.132	std
73	7.85	.609	.131	2
74	5.03	.228	.120	3
75	6.59	.531	.060	2
76	9.20	.759	.401	2
77	7.05	.502	.041	2
78	6.92	.453	.000	2
79	8.96	.831	.489	2
80	5.58	.319	.099	3
81	7.10	.470	.006	2
82	4.78	.173	.126	3
83	5.48	.259	.097	3
84	5.40	.262	.091	3
85	6.51	.426	.009	3
86	7.05	.463	.001	2
87	8.58	.743	.352	2
88	7.78	.539	.059	3
89	6.02	.335	.037	3
90	6.40	.413	-.001	2
91	8.94	.883	.545	2
92	8.66	.741	.339	2
93	9.40	.883	.621	2
94	6.62	.431	-.005	3
95	4.66	.240	.087	3
96	8.51	.841	.487	2
97	7.94	.634	.146	2
98	9.23	.448	-.005	2
99	9.38	.851	.597	2
100	6.02	.381	.021	2
101	6.65	.433	.012	2
102	7.54	.603	.111	2
103	5.79	.307	.061	2
104	4.27	.123	.113	2
105	7.53	.575	.095	2
106	7.96	.669	.205	2
107	5.39	.252	.121	2
108	4.68	.155	.115	2
109	9.40	.817	.447	2
110	8.86	.687	.245	2
111	5.40	.253	.081	2
112	5.37	.187	.125	3
113	7.26	.549	.079	2
114	8.54	.723	.307	2
115	9.09	.843	.530	2
116	9.01	.821	.511	2
117	9.67	1.065	.921	2
118	7.74	.580	.111	2
119	7.12	.559	.065	2
120	7.34	.735	.321	2
121	7.29	.504	.028	2

TABLE 2a cont'd

Star No.	V	B-V	U-B	n
122	6.76	.541	.050	2
123	5.10	.214	.118	2
124	6.27	.497	.059	2
125	9.31	.489	- .044	3
126	6.37	.291	.064	2
127	8.89	.736	.345	2
128	6.75	.450	- .005	2
129	4.64	.145	.135	2
130	5.43	.242	.143	2
131	6.01	.270	.037	2
132	8.54	.665	.251	2

TABLE 2b

133	9.67	.611	.057	4
134	10.04	.651	.162	3
135	8.98	.886	.622	3
136	7.42	1.108	.952	2
137	5.89	.324	.041	2
138	8.29	.865	.501	2
139	9.10	.650	.139	3
140	8.94	.757	.337	2
141	4.48	.253	.133	2
142	8.34	.665	.205	2
143	7.90	.525	.059	2
144	9.09	.507	- .026	3
145	9.33	.778	.359	2
146	7.24	.531	.063	2
147	9.17	.545	.053	3
148	8.93	.605	.077	2
149	8.50	.617	.094	3
150	8.79	1.036	.621	2
151	9.93	.945	.703	2
152	9.25	.941	.604	2

TABLE 2c

Star No.	B.D.	V	B-V	U-B	n
153	29° 503	8.91	.859	.570	3
154	20° 480	5.80	.409	.009	3
155	24° 846	9.48	.529	.071	2
156	29° 936	10.38	.724	.317	2
157	25° 373	5.79	.443	.036	3
158	11° 456	8.03	.609	.134	3
159	18° 514	8.74	.516	- .005	2
160	7° 592	5.46	.363	- .001	3
161	25° 674	9.05	.843	.527	2
162	20° 721	7.84	.705	.266	3
163	-1° 697	7.98	.370	.028	3
164	18° 719	6.01	1.210	1.324	3
165	23° 747	8.52	.615	.190	2
166	17° 807	9.59	.515	.070	2
167	28° 783	8.92	.478	.017	2
168	16° 822	5.54	.220	.103	2
169	9° 1064	4.12	.154	.081	3

TABLE 2d

170	23° 571	10.21	1.185	1.045	2
171	14° 685	10.10	.709	.246	2
172	13° 671	10.20	.635	.133	2
173	15° 616	10.49	1.237	1.180	3
174	17° 715	9.99	1.058	.951	2
175	16° 593	10.30	1.031	.928	3
176	17° 721	9.01	.939	.659	3
177	13° 684	10.57	1.123	1.004	2
178	13° 685	9.00	.837	.529	2
179	14° 699	9.52	.934	.703	2
180	16° 609	9.10	.853	.580	2
181	15° 634	10.32	1.167	1.079	4
182	15° 638	8.93	.844	.487	3
183	15° 650	9.69	.910	.680	3
185	16° 640	9.48	1.105	.922	2
186	19° 754	9.98	1.402	1.256	3
187	13° 783	8.97	.761	.374	2
188	Gron. 205	11.07	.805	.392	3
189	Gron. 215	11.13	1.368	1.242	3
190	Gron. 229	10.71	1.357	1.177	3
191	Gron. 283	11.03	1.291	1.262	4

It would seem reasonable, on the basis of the foregoing arguments, to conclude that the existence of subdwarfs in the Hyades has been established. However, as Figure 3 shows clearly, the space distribution of these "subdwarfs" is very different from that of the cluster main-sequence stars: if these stars are cluster members, ***they occur only in the outer regions of the cluster***. It is possible, of course, to assume that these "subdwarfs" are not actually cluster members but are, instead, main-sequence objects situated beyond

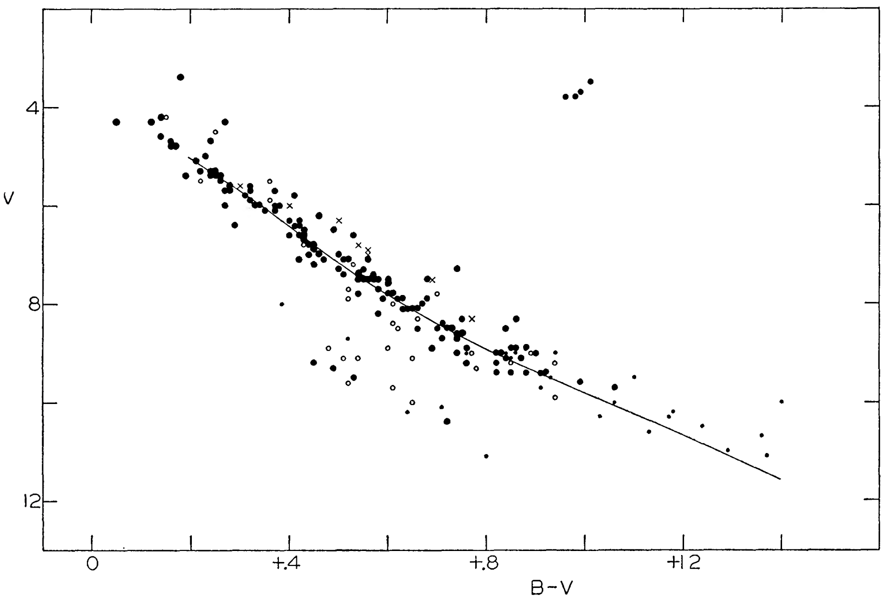

FIG. 1 —The color-magnitude diagram for the Hyades *Large spots:* Proper motions and radial velocities indicate membership *Open circles:* Proper motions indicate cluster membership, or proper motions and radial velocities indicate possible membership *Small spots:* Fainter stars, possible cluster members. *Crosses:* double stars

TABLE 3

MAIN SEQUENCES OF THE HYADES AND PRAESEPE CLUSTERS

$B-V$	V		PR−HY	MEAN M_v*
	Hyades	Praesepe		
+0 2	5 1	8 2	+3 1	2 14
+0 3	5 75	8 65	+2 9	2 69
+0 4	6 35	9 4	+3 05	3 36
+0 5	7 15	10 1	+2 95	4 12
+0 6	7 8	10 8	+3 0	4 79
+0 7	8 4	11 3	+2 9	5 34
+0 8	8 95	11 8	+2 85	5 86
+0 9	9 35	12 3	+2 95	6 32
+1 0		12 75		6 76
+1 1		13 1		7 11
+1 2		13 65		7 66
+1 3		14 1		8 11
+1 4		14 6		8 61
Mean			+2 96	

* Computed by using a distance modulus for the Hyades of 3 03 mag (van Bueren 1952)

the cluster. This assumption leads, however, to the improbable circumstance in which we find a "cluster" of high-velocity (~110 km/sec) stars at about two and a half times the distance of the Hyades. This comes about because the proper motions of these stars and, in four cases, the radial velocities are in agreement with the motion of the Hyades cluster. The space velocity of the Hyades is about 44 km/sec and the proper motion about 0".1 per year.

II. THE COMA BERENICES STAR CLUSTER

During the last three years (1953, 1954, 1955) occasional observations have been made, during the course of other work, on the members of the star cluster in Coma Berenices. The observations were made with the same equipment and in the same fashion as for the Hyades. The colors and magnitudes of the Coma Berenices stars are given in Table 5. The fifth column gives the number of observations on each star. Star No. 146

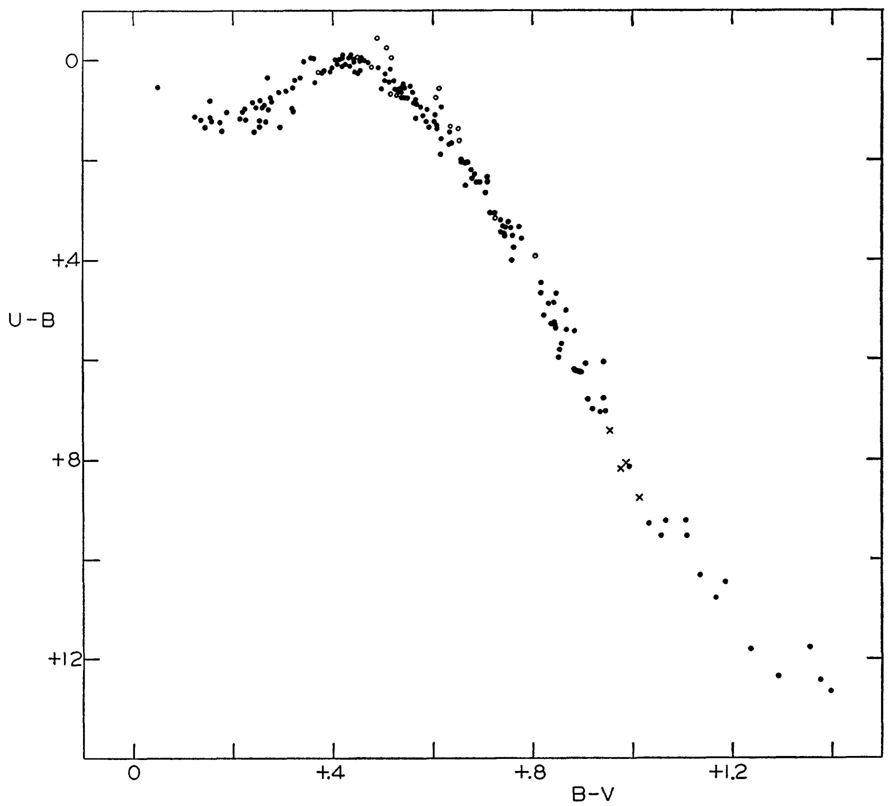

FIG 2.—$U - B$ versus $B - V$ for the Hyades. *Open circles:* Stars below the main sequence in Fig 1

TABLE 4

THE "SUBDWARFS" IN THE HYADES

98	147	166	134	156	172*
125	148	167	139	159	188*
133	155	171*	144	163	

* No 171 = Osvalds' (1954) No 125, "probable member"
No 172 = Osvalds' (1954) No 197, "certain member"
No 188 = Osvalds' (1954) No 469, "certain member."

was used as the single standard star for the cluster. The probable errors of the zero points are listed in Table 6*a*, and the probable errors with respect to the cluster standard in Table 6*b*.

The color-magnitude diagram, V versus $B-V$, for the Coma cluster is given in Figure 4, which shows no features not reported earlier by Weaver (1952), except for the addition of several faint stars that probably are cluster members.

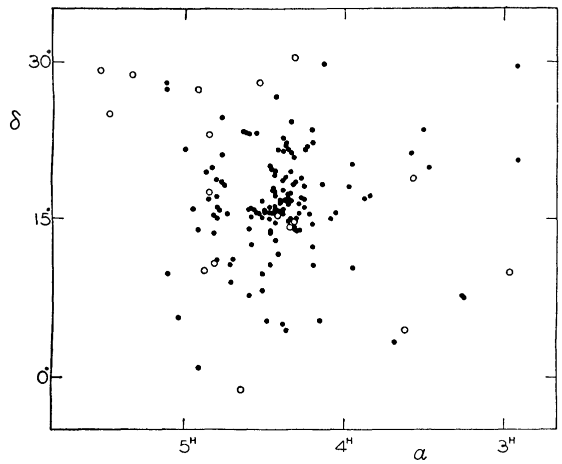

FIG 3 —The position in the sky of the Hyades stars. *Open circles:* Stars below the main sequence in Fig 1.

TABLE 5

MAGNITUDES AND COLORS OF STARS IN COMA BERENICES STAR CLUSTER

Star No *	V	$B-V$	$U-B$	n	Star No *	V	$B-V$	$U-B$	n
10	6 04	+0 114	+0 106	3	107	5 18	+0 076	+0 106	3
19	8 12	+ 397	− 030	3	109	6 42	+ 266	+ 075	3
36	8 13	+ 407	− 036	3	111	8 17	+ 518	− 008	3
49	7 89	+ 353	+ 058	3	114	8 60	+ 453	− 044	2
53	8 73	+ 525	+ 020	2	118	8 37	+ 449	− 022	2
58	8 83	+ 510	+ 013	2	125	4 95	+ 273	+ 177	2
60	6 48	+ 181	+ 088	3	130	5 00	+ 081	+ 128	2
62	6 27	+ 167	+ 147	2	132	9 91	+ 679	+ 188	2
65	9 02	+ 566	+ 049	2	139	6 76	+ 163	+ 096	2
68	6 67	+ 177	+ 094	3	144	6 54	+ 179	+ 109	2
76	9 10	+ 547	+ 028	3	145	6 65	+ 207	+ 088	2
82	7 42	+ 275	+ 026	3	146	5 29	− 049	− 118	Std
85	9 34	+ 589	+ 062	2	150.	9 78	+ 776	+ 314	2
86	8 55	+ 463	− 019	2	160	5 46	+ 049	+ 104	5
90	8 56	+ 461	− 044	2	162	8 61	+ 475	− 044	2
91	4 83	+ 497	+ 264	3	183	6 29	+ 108	+ 096	2
92	8 61	+ 535	+ 002	2	A3.	10 81	+ 895	+ 572	3
97	9 12	+ 540	+ 011	2	A13	10 51	+ 773	+ 384	3
101	8 42	+ 443	− 024	2	A14	10 00	+ 793	+ 332	3
102	9 36	+ 594	+ 080	3	A21	10 38	+0 834	+0 422	3
104	6 73	+0 237	+0 050	2					

* Star numbers according to Trumpler (1938)

The relationship between the two color indices, $U-B$ versus $B-V$, is shown in Figure 5. Note that the two yellow-white giant stars in Figure 4 deviate from the main-sequence stars in the direction discussed earlier: the higher the luminosity of the star, the lower the intensity of ultraviolet radiation.

III. COMPARISONS OF $U-B$ AMONG THE PRAESEPE, HYADES, AND COMA BERENICES CLUSTERS

The relationships between $U-B$ and $B-V$ for the three clusters—the Hyades, the Coma cluster, and Praesepe—are compared in Figure 6. The Hyades and Coma clusters are represented by the solid lines, while Praesepe is represented by the spots. It is evident that in the region of $B-V$ around $+0.4$ the Coma cluster stars have stronger ultraviolet radiation by about 0.035 mag. than do the stars of the other two clusters. This small difference is fairly well established (compare the probable errors of the zero points in Tables 1 and 5*a* and 5*b*) and has been checked by special intercluster transfers.

TABLE 6*a*

PROBABLE ERRORS (MAG.) OF TIE-IN OF COMA BERENICES CLUSTER STANDARD WITH U, B, V SYSTEM

V	$B-V$	$U-B$
±0 010	±0 005	±0 010

TABLE 6*b*

PROBABLE ERRORS (MAG.) OF COMA BERENICES CLUSTER OBSERVATIONS WITH RESPECT TO CLUSTER STANDARD, FOR ONE OBSERVATION

V	$B-V$	$U-B$	
±0 006	±0 005	±0 010	$V<9$ 5
±0 011	±0 017	±0 025	$V>9$ 5

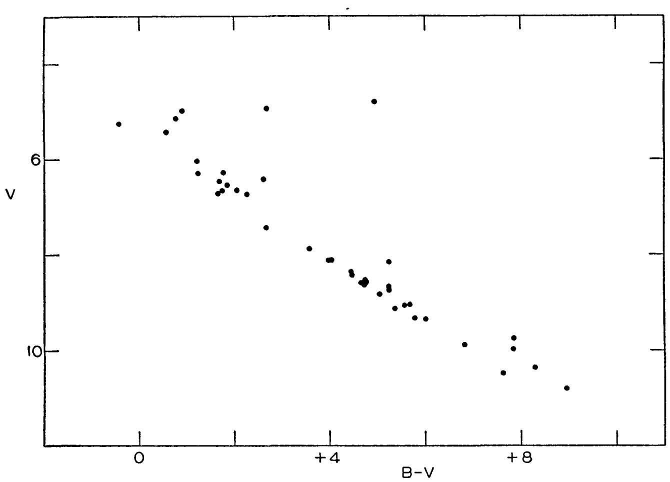

FIG. 4.—The color-magnitude diagram for the star cluster in Coma Berenices

While the deviation of the Coma cluster stars from those of the Hyades is in the same sense as that for the "subdwarfs" in the Hyades, it is not reasonable to suppose that this comparison suggests that the Coma cluster main-sequence stars are subdwarfs, since the spectra of these stars indicate that they are normal main-sequence objects (Weaver 1952). A more reasonable explanation is in terms of Miss Roman's (1950) strong-line and weak-line stars. The Coma cluster stars might be expected to belong to her weak-line class, and the Hyades and Praesepe stars to her strong-line class. We see, therefore, that, while there seem to be fairly well-defined correlations between $U-B$ and luminosity for the F and G stars in a given cluster, there probably are systematic differences between clusters, caused perhaps by differing chemical composition, that mask much of this luminosity effect. The near-by bright stars provide a heterogeneous sample of stars such as we might find in galactic clusters in general, and among such stars a considerable scatter in $U-B$ is found for F and G main-sequence stars (Johnson and Morgan 1953).

IV. COMPARISON OF THE HYADES-PRAESEPE MAIN SEQUENCE WITH THAT OF THE PLEIADES

If we fit the Pleiades main sequence to the Hyades-Praesepe sequence in the range of $B-V = +0.5$ to $+0.6$ (the reddest that the Pleiades main sequence has been meas-

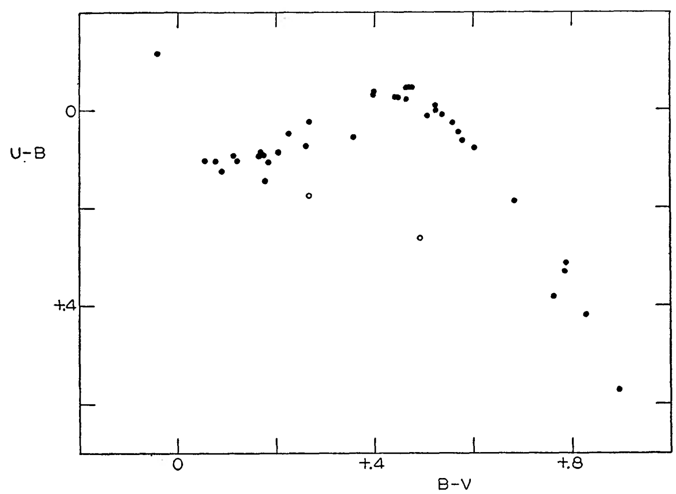

FIG. 5.—$U - B$ versus $B - V$ for the Coma Berenices star cluster *Open circles:* The two yellow-white giants in Fig. 4.

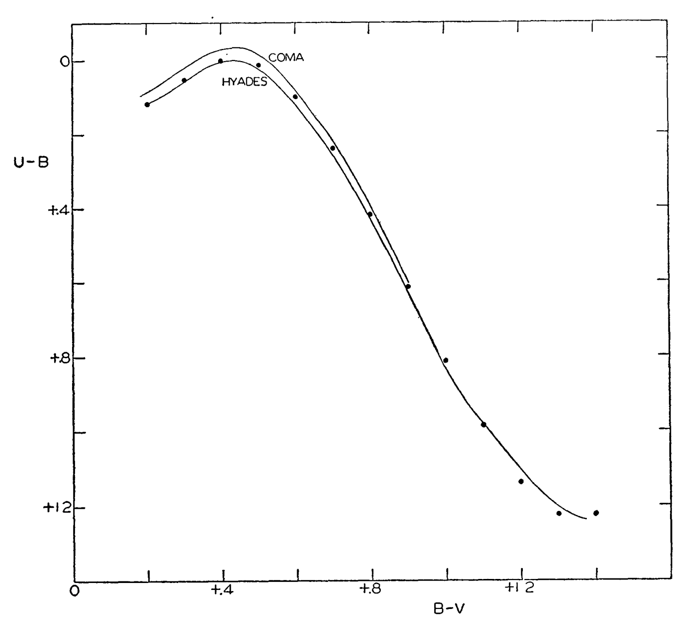

FIG. 6.—$U - B$ versus $B - V$ for three clusters, Coma, Hyades, and Praesepe (*spots*)

ured photoelectrically), we find, as is shown in Figure 7, that the blue end of the Pleiades main sequence falls below the Hyades-Praesepe main sequence. This deviation is in the direction we would expect from certain current theories of stellar evolution (Schönberg and Chandrasekhar 1942; Harrison 1944), since the Pleiades is a younger cluster than either the Hyades or Praesepe. If we assume that the age of a cluster can be computed from the absolute magnitudes and the masses of the stars in the region of the color-magnitude diagram where the cluster sequences deviate strongly from the main sequence

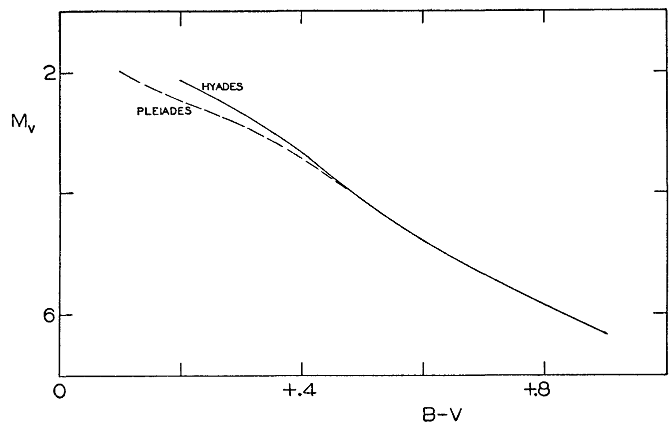

FIG 7 —Comparison of the main sequences of the Hyades and the Pleiades

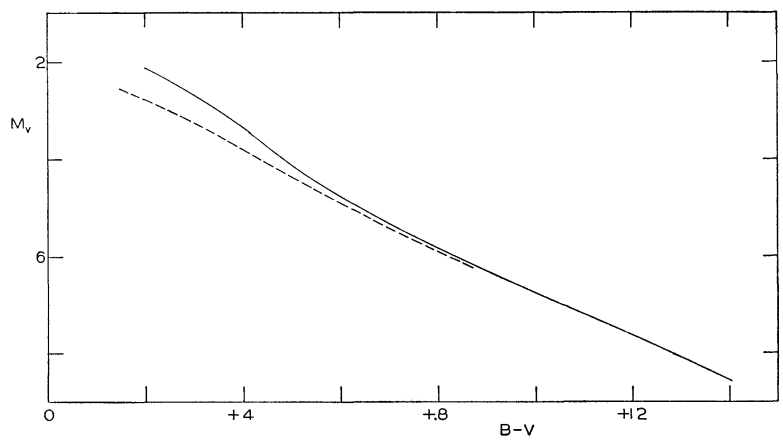

FIG. 8 —The "original" main sequence (*dotted line*) computed from the present Hyades-Praesepe main sequence (*solid line*).

(see eq. [24] of Strömgren 1952), the age of the Pleiades is about 2×10^8 years and that of the Hyades and Praesepe about 1×10^9 years.

The theory of the generalized Cowling model, as developed by Harrison (1944), enables us to compute from the observed sequence the "original" position of the Hyades-Praesepe main sequence, assuming that the age of the clusters is 1×10^9 years. The dotted line in Figure 8 represents this computed main sequence. Compare Figure 8 with Figure 7.

Figure 8 shows that when we fitted the Pleiades main sequence to the Hyades-Praesepe main sequence at $B-V = +0.5$ to $+0.6$, we placed the Pleiades main sequence about 0.2 mag. too high. This comes about because the Hyades-Praesepe stars at $B-V = +0.5$ to $+0.6$ have already evolved somewhat. Figure 9 shows a comparison between the main sequence for an age of 2×10^8 years (computed from the Hyades-Praesepe main sequence) and the observed Pleiades main sequence fitted to the *computed* main sequence at $B-V = +0.6$. The dotted line represents the Pleiades, while the spots represent the values computed from the Hyades-Praesepe main sequence. The agreement between the two is quite good; the computed values even suggest something of the observed shape of the Pleiades main sequence. This comparison of cluster observations with theory indicates that the evolutionary theory initiated by Schönberg and Chandrasekhar (1942) and developed further by Harrison (1944) may, in fact, describe rather closely the actual physical processes that take place in these stars.

The distance modulus for the Pleiades cluster that we obtain by the procedure above is about 5.3 mag. (corrected for interstellar absorption), corresponding to a distance of about 114 parsecs, compared with the previous value of 144 parsecs (Johnson and Morgan 1953). The new value is in closer agreement with the geometrically determined distance (Gratton 1938).

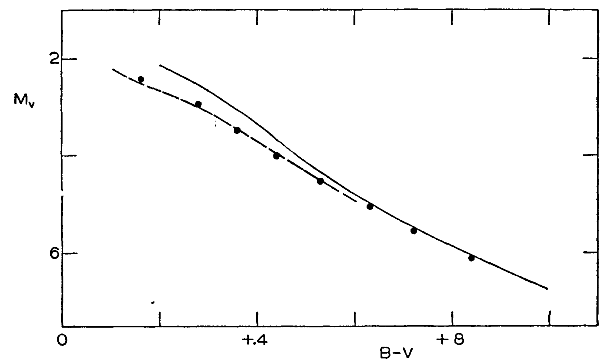

FIG 9 —Comparison of the Pleiades main sequence (*dotted line*) with values (*spots*) computed from the Hyades-Praesepe main sequence (*solid line*).

V. COMPARISONS OF THEORETICAL MAIN SEQUENCES OF DIFFERENT AGES WITH NEAR-BY STARS

The computed main sequences for various ages (starting from the observed Hyades-Praesepe main sequence at an age of 1×10^9 years) are compared in Figure 10 with near-by stars of luminosity class V, for which trigonometric parallaxes having probable errors smaller than 10 per cent have been measured (*spots*) and the mean absolute magnitudes determined from large groups of stars with measured trigonometric parallaxes (*open circles*). The individual stars (*spots*) were selected from Table 3 of Johnson and Morgan (1953); the trigonometric parallaxes for these stars were taken from the Yale *Catalogue of Stellar Parallaxes* (Jenkins 1952). The mean values (*open circles*) were taken from the calibrations given by Morgan and Keenan (Hynek 1951) for stars of luminosity class V, transformed to $V-B$ by means of the tabulated relationship between MK and $B-V$ given by Johnson and Morgan (1953). The open circles represent, therefore, the mean values for groups of stars. The lines labeled *0*, *1*, and *5* are the computed main sequences for 0, 1, and 5×10^9 years, respectively. (The 1×10^9-year line is, of course, the observed line for Hyades-Praesepe.)

Note, first, the close agreement of the computed main sequences with the near-by stars, especially the open circles, for $B-V > +0.8$. Remember that the Hyades-Praesepe line was fixed in absolute magnitude by the *geometrical* parallax of the Hyades cluster and that the Praesepe main sequence was used only as a sort of interpolation formula for the Hyades that, as Figure 1 shows, fits the Hyades observations quite satisfactorily except possibly at the red end ($B-V > +1.2$), where very few Hyades were observed. This close agreement of cluster main sequence with near-by stars ($B-V > +0.8$), obtained by the use of *geometrical parallaxes only*, indicates, since the near-by stars may be assumed to be a heterogeneous mixture of stars of all ages, that the initial main sequence (age = 0) is quite narrow and well represented ($B-V > +0.8$) by our computed main sequence for age 0.

Let us next direct our attention to the bluer stars. Here we find that the lines for age = 0 and 5×10^9 years bound the region occupied by the near-by stars. This is precisely the result we would expect if the near-by stars were a heterogeneous mixture of stars of all ages from 0 to 5×10^9 years. We note that the calibration points of Keenan and Morgan (*open circles*) fall above the main sequence for age 0 (and in part of the diagram above the Hyades-Praesepe line), just as we would expect if the stars of luminosity class

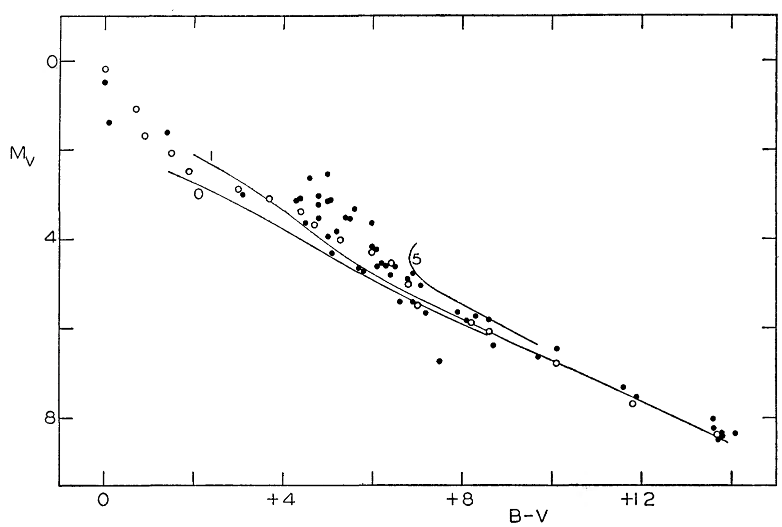

FIG. 10.—Comparison of the theoretical main sequences of age = 0, 1×10^9, and 5×10^9 years with near-by stars *Spots:* Individual near-by stars *Open circles:* Keenan and Morgan's calibration of luminosity class V

V were a mixture of stars that had evolved various distances (with an arbitrary upper limit) from the original main sequence.

The later stages of stellar evolution had been discussed theoretically by Sandage and Schwarzschild (1952) and from the standpoint of observation by Johnson (1954).

VI. CONCLUSION

We have presented three-color photoelectric observations of the Hyades and Coma Berenices star clusters. The Hyades main sequence is very similar to Praesepe's, and a mean line that represents the Hyades main sequence satisfactorily has been derived. The absolute-magnitude calibration for this line has been obtained from the geometrical parallax for the Hyades cluster given by van Bueren (1952).

A number of stars, probably cluster members according to their proper motions and (four stars) radial velocities, that fall about 2 mag. below the main sequence are found in the Hyades. If these stars are cluster members, they occur only in the outer regions of the cluster. It would be of considerable interest to investigate the proper motions of faint stars in the outer regions of Praesepe, to see whether this cluster also has a relatively large population of subdwarfs at large distances from the cluster center. Four subdwarfs are already known in the Praesepe cluster.

Ultraviolet observations in the Coma Berenices star cluster show that its F- and G-type stars probably radiate about 0.035 mag. more ultraviolet than do similar stars in the Hyades.

A comparison of the Hyades-Praesepe main sequence with the observed Pleiades main sequence shows differences between the clusters that are in the same direction and approximately the amount predicted by the theory of the generalized Cowling model.

A comparison is made of the theoretical main sequences for different ages with near-by stars. All absolute-magnitude calibrations are geometrical, either trigonometric parallaxes (near-by stars) or the cluster parallax of the Hyades. This comparison indicates that the initial main sequence (age 0) is fairly narrow and that the oldest among the near-by stars may be around 5×10^9 years old. The agreement of theory with observation indicates that the theory of the generalized Cowling model may describe rather closely the actual physical processes taking place in the stars during the earlier stages of their evolution.

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