SPECTRA, COLORS, LUMINOSITIES, AND MOTIONS OF THE WHITE DWARFS

OLIN J. EGGEN AND JESSE L. GREENSTEIN
Mount Wilson and Palomar Observatories, Carnegie Institution of Washington
California Institute of Technology
Received August 17, 1964

ABSTRACT

Spectroscopic and photometric data, most of which are new, are given for 166 white dwarfs in Table 1 together with the available astrometric data. An $(M_V, U - V)$ diagram is constructed for 19 stars with trigonometric parallaxes greater than 0.05″, 16 stars in the Pleiades, Hyades, and Praesepe clusters, and 34 stars in wide binary systems. The red components in many of the wide binaries have been observed in the $(R - I)$ as well as in the (UBV) system; low-dispersion spectra of some of these objects are also discussed.

The white dwarfs are divided into two groups: (1) those that cluster, with very little dispersion, about the relation $M_V = +11.65^m + 0.85\ (U - V)$, and (2) those that show a somewhat larger dispersion about a similar, but steeper, relation with a zero-point approximately 1.5 fainter. This well-marked separation is also reflected in the nature of the spectral lines, with those in group (1) showing appreciably sharper absorption lines than the fainter stars. Group 1 stars are mainly sharp-lined DA objects, whereas the "peculiar" (i.e., non-DA) stars fall in group 2.

Many stars of individual interest, as well as various correlations involving the equivalent widths of Hγ in the DA stars and the colors and the departure of the stars from black bodies, are discussed in detail. Spectroscopically some of the most interesting stars include the DK and DM objects which are available for the first time in many numbers.

The four known λ 4670 stars, which includes one new member of this class, may form a moving group, as previously suggested by Bell (1962). This group, called the W219 group, may also include two stars of type DC and one of type DK.

I. INTRODUCTION

Extensive reviews of the older observational data and theoretical interpretations of white dwarfs are available elsewhere (Greenstein 1958; Schatzman 1958); some more recent spectroscopic results have been published by Greenstein (1960) and analyzed by Weidemann (1963). Table 1 contains 166 objects that, with one or two exceptions described in the notes to the table, are almost certainly white dwarfs on the basis of available colors and spectra; a few stars are included on the basis of their colors and proper motions alone. The table* contains the following information:

Column I. Name/α/δ. The positions are for 1950. The name, in most cases, is that given by the discoverer of the proper motion or of the blue color. The abbreviations used are: G = Giclas *et al.*, L = Luyten, W = Wolf, R = Ross, Ox = Oxford AG, Gw = Greenwich AG, He = Hertzsprung, HZ = Humason-Zwicky, V Ma = van Maanen, SA = Selected Area, F = Feige, HG = Giclas (Hyades), Ton = Tonantzintla, and C = Case. The various discovery lists by Giclas *et al.* are referred to as Giclas (1962), and by Luyten as Luyten (1962).

Column II. $V_E/B - V/U - B$. Photoelectrically determined colors and magnitudes.

Column III. Source of photometry/$\mu_\alpha \cos \delta/\mu_\delta$. The proper motion components are in seconds of arc. The photometry is mostly based on new observations with the 100- or 60-inch reflectors at Mount Wilson and with the 200-inch reflector at Palomar. For

* By error, the two consecutive stars LB3303 and G5-28 were given the same running number, 21; they should be referred to as 21a and 21b. In addition, five new DA stars, not in Table 1, have recently been confirmed spectroscopically; they are G132-12, G154B5B, G155-15, G155-19, and G156-64. The latter is composite.

TABLE 1

MAGNITUDES, COLORS, SPECTRAL TYPES AND MOTIONS OF WHITE DWARFS

No.	I	II	III	IV	V	VI	VII	VIII	IX
1	G130-49 $0^{h}07^{m}.0$ $+30^{\circ}52'$	$16^{m}.85$ +0.25 -0.70	100(3) $-0''.37$ $-0''.41$	---- ---- ----	---- ---- ----	-170 +4 -103	+33 +79 -51	-224 +5 -135	----- +12.4:* G130-49
2	W1 0 11.1 +0 03	15.31 +0.24 -0.58	1 +0.48 -0.22	(DA)	+93 -117 -51	+42 -54 -24	+11 +47 -88	+147 -185 -81	+11.3 +13.0 G31-35
3	LB 433 0 17.4 +13 36	15.22 -0.12 -0.97	100(1) +0.036 +0.008	DB 10.5 25	+11 -4 0	---- ---- ----	+25 +62 -75	+16 -6 0	+10.8 ----- F4
4	L1011-71 0 33.1 +1 37	15.52 +0.24 -0.68	1 +0.44 0.00	DA	+102 -62 -7	+62 -37 -4	+21 +44 -87	+178 -108 -13	+11.3 +12.8 G1-8
5	V Ma2 0 46.5 +5 10	12.36 +0.56 +0.04	1 +1.260 -2.700	DG* 25 19	---- ---- ----	-6 -85 -67	+28 +46 -84	-86 -122 -69	----- +14.2* G21-27
6	L796-10 0 53.3 -11 45	15.26 +0.35 -0.50	1 0.00 -0.47	(DA)	-74 -113 -38	-29 -45 -15	+16 +22 -96	-118 -179 -60	+11.5 +13.4 L7
7	G1-45 1 01.2 +4 48	14.10 +0.14 -0.50	60(1) +0.27 +0.36	DAs 17.1 23	+58 +16 +31	+33 +9 +18	+33 +42 -85	+183 +49 +97	+11.4 +12.8 G1-45
8	L1373-25 1 07.5 +26 45	14.93 +0.09 -0.64	100(1) +0.36 +0.27	DA 44.1 58	+94 -18 +63	+58 -9 +31	+50 +64 -58	+176 -32 +116	+11.2 +12.7 -----
9	W1516 1 15.4 +15 56	13.82 +0.11 -0.80	100(1) 0.00 -0.65	DC	-42 -71 -77	-20 -34 -37	+46 +51 -72	-114 -193 -211	+11.0 +12.6 L8
10	R548 1 33.7 -11 36	14.10 +0.20 -0.54	100(1) +0.43 -0.07	(DA)	+51 -55 +10	+23 -25 +4	+30 +12 -94	+140 -150 +26	+11.3 +13.0 L9
11	L870-2 1 35.4 -5 14	12.84 +0.34 -0.50	1 +0.57 -0.34	DAs 6.0 7	+13 -30 -1	---- ---- ----	+37 +20 -90	+125 -288 -13	+11.8* ----- L10
12	G34-49 1 42.6 +23 09	17.41 -0.05 -0.62	200(2) +0.29 -0.11	DC	---- ---- ----	+49 -64 -6	+59 +52 -61	+90 -116 -12	----- +13.7* G34-49
13	G94-9 1 43.9 +21 40	15.05 +0.25 -0.65	100(2) -0.25 -0.12	DA (24) (31)	-59 +22 -37	-29 +11 -19	+59 +50 -63	-106 +39 -67	+11.3 +12.8 G94-9
14	G71-B5B 1 50.5 +8 57	17.16 +0.21 -0.81	200(1) +0.04 -0.09		---- ---- ----	-2 -31 -16	+53 +34 -77	-32 -418 -207	----- +12.8* G71-B5
15	$Ox25^{\circ}6725$ 2 05.9 +25 00	13.22 -0.04 -0.85	100(2) +0.421 -0.121	(DA) (36)	+40 -48 +6	---- ---- ----	+67 +48 -57	+130 -159 +18	+10.8 ----- L11
16	G134-22 2 13.8 +42 44	16.23 +0.73 +0.02	200(1) +0.85 -0.64	DC	---- ---- ----	+54 -75 -27	+72 +62 -30	+281 -393 -144	----- +14.8 G134-22
17	h Per 1166 2 14.0 +56 53	13.68 -0.12 -0.92	2 +0.16 -0.01	(DA)	+21 -20 +8	---- ---- ----	+70 +71 -6	+53 -50 +2	+10.7 ----- L12
18	G94-B5B 2 20.7 +22 14	15.83 +0.07 -0.71	100(3) +0.14 -0.06	DAn (42) (59)	---- ---- ----	+15 -24 +1	+70 +41 -58	+38 -61 +2	----- +12.5* G94-B5
19	F22 2 27.7 +5 03	12.65 -0.06 -0.83	100(1) +0.095 -0.019	DA 27.4 39	+9 -13 +2	---- ---- ----	+62 +19 -76	+26 -36 +12	+10.9 ----- F22
20	F24 2 32.5 +3 31	12.25 -0.23 -1.25:	60(1) +0.083 +0.010	DA*wke 4.5 25	+7 -5 +4	---- ---- ----	+62 +16 -77	+27 -22 +18	+10.4 ----- F24
21	LB3303 3 10.0 -68 48	$11^{m}.2$ ---- ----	---- $+0''.08$ $-0''.01$	(DA*) (38) (36)	+3: -5: +4:	---- ---- ----	-20 -69 -69	+17 -27 +22	+10.0: ----- -----
21	G5-28 3 15.7 +15 02	$15^{m}.54$ +1.32 +0.38	100(4) +0♀012 $-0''.285$	DMp:*	---- ---- ----	+2 -18 -22	+80 +18 -57	-35 -103 -82	ρ = +10.9 +14.1* G5-28
22	L587-77A 3 26.8 -27 34	14.0 ---- ----	----- +0.71 +0.36	DAs	+74: -29: +52:	---- ---- ----	+42 -38 -82	+295 -115 +205	+12.0: ----- L14
23	G37-44 3 32.1 +32 02	15.50 +0.21 -0.55	100(3) +0.36 -0.31	DA 30.6 35	+54 -146 -7	+25 -67 -3	+88 +34 -33	+78 -211 -11	+11.3 +13.0 G37-44
24	W219 3 41.6 +18 18	15.20 +0.30 -0.52	1 +0.47 -1.16	4670	---- ---- ----	-4 -82 -32	+87 +15 -47	-24 -551 -217	----- +14.4* L15
25	LB1497* 3 49.1 +24 47	16.52 -0.20 -1.10	200(2) +0.038 -0.052	DAwk (25) (66)	+6 -37 -7	---- ---- ----	+90 +21 -38	+5 -30 -6	+11.0* ρ = +5 -----
26	HZ4 3 52.1 +9 37	14.47 +0.15 -0.67	1 +0.152 -0.008	DA 38.4 55	+41 -20 -2	---- ---- ----	+84 0 -53	+28 -50 +44	+11.5* ρ_c = +36.0 -----
27	G7-17 3 58.7 +18 36	15.52 +1.83 +1.14	200(3) +0.30 -1.20	DM:* 7.4 18	---- ---- ----	-9 -77 -34	+90 +10 -42	-63 -519 -264	----- +14.7* G7-17
28	LB1240 4 01.5 +25 01	13.80 +0.10 -0.58	60(3) +0.13 -0.21	DA 32.1 46	---- ---- ----	+35 -17 -16	+92 +18 -34	+13 -114 -26	ρ_c = +36.0 +12.3* G8-8
29	LB227 4 06.3 +16 59	15.35 +0.09 -0.65	100(1) +0.116 -0.023	DA 41.2 58	---- ---- ----	+40 -17 -2	+90 +6 -42	+17 -44 +30	ρ_c = +36.7 +12.4* HG7-112
30	HZ10 4 07.3 +17 54	14.14 +0.17 -0.58	1 +0.070 -0.076	DA 37.4 42	+35 -16 -15	---- ---- ----	+91 +7 -41	+4 -49 0	+11.1* ρ_c = +37.0 L17
31	HZ2 4 10.1 +11 45	13.86 -0.05 -0.88	1 +0.051 -0.086	DA 22.7 42	+32 -18 -20	---- ---- ----	+89 -2 -46	-4 -47 -7	+10.9* ρ_c = +37.3 -----
32	HG7-138 4 12.4 +14 57	15.65 +1.05 +0.32	100(2) +0.090 -0.030	DK 3.8 12	+38 -15 -7	---- ---- ----	+91 +2 -42	+10 -38 +21	+12.6* ρ_c = +37.5 HG7-138
33	40 Eri B 4 13.0 -7 44	9.52 +0.03 -0.68	200(2) 2.229 3.420	DA 31.3* 39	-97 -12 -41	---- ---- ----	+74 -28 -62	-1305 -480 -1345	+11.0* ρ = -42.2 -----
34	G38-29 4 17.0 +36 09	15.63 +0.16 -0.53	100(3) +0.04 -0.28	DAs 33.7 34	+11 -65 -46	+6 -35 -25	+94 +28 -17	+19 -108 -78	+11.3 +13.0 G38-29
35	LB212 4 18.9 +15 22	16.62 +0.14 -0.57	200(1) -0.021 -0.004	DAwk	-5 +7 -10	-2 +3 -5	+92 +1 -40	-4 +5 -8	+11.2 +12.7 -----
36	VR7 4 21.0 +16 14	14.29 -0.02 -0.84	1 +0.100 -0.020	(DA) (32)	+40 -15 -3	---- ---- ----	+92 +1 -38	+12 -37 +28	+11.3* ρ_c = +38.1 HG7-191
37	VR16 4 25.7 +16 52	14.02 -0.09 -0.97	1 +0.099 -0.014	(DA) (25)	+40 -14 -2	---- ---- ----	+93 +1 -36	+12 -35 +30	+11.0* ρ_c = +38.5 HG7-233
38	HZ9 4 29.4 +17 38	13.95 +0.33 -0.69	1 +0.102 -0.034	DAe* 30.2 (50)	+40 -17 -3	---- ---- ----	+94 +1 -34	+10 -43 +26	+11.0 ρ = +38.8 HG7-255
39	HZ7 4 31.0 +12 35	14.18 -0.03 -0.89	1 +0.089 +0.001	DA 23.7 46	+40 -13 -3	---- ---- ----	+92 -6 -39	+11 -26 +31	+11.2* ρ_c = +39.0 -----
40	G39-27 4 33.6 +27 04	15.94 +0.65 -0.06	100(2) +0.264 -0.137	DC	---- ---- ----	+38 -16 0	+96 +13 -23	+29 -128 +51	ρ = +36 +14.9* G39-27
41	L879-14 4 35.4 -8 53	$14^{m}.10$ +0.14 -0.65	60(1) $+0''.23$ $-1''.47$	4670	-150 -210 -70	-76 -106 -34	+75 -35 -55	-395 -554 -;83	+11.2 +12.7 -----

TABLE 1—*Continued*

I	II	III	IV	V	VI	VII	VIII	IX
42 HZ14	13^{m}83	1	DAn	+42	----	+92	+11	+10.8*
4 38.2	-0.15	+0$''$085	20.7	-13	----	-10	-21	ρ_c = +40.2
+10 53	-1.04	+0$''$010	33	0	----	-38	+33	-----
43 G86-B1B	16.20	200(3)	DAe	----	+5	+99	+10	-----
5 18.4	+0.31	+0.17	(19)	----	-36	+11	-73	+12.7*
+33 19	-0.64:	-0.07	(37)	----	+24	-3	+4	G86-B1
44 G102-39	15.86	200(3)	DC	----	-16	+96	-39	-----
5 51.1	+0.05	-0.03		----	-45	-26	-107	+12.9*
+12 24	-0.76	+0.29		----	-32	-12	-78	G102-39
45 LP658-2	14.52	200(2)	DKe*	----	-42	+84	-603	-----
5 52.7	+1.06	+0.574	2.0	----	-64	-49	-911	+15.4*
-4 09	+0.81	-2.293	10	----	-17	-25	-248	G99-44
46 L1244-26	13.40	1	DA	-12	----	+97	-34	+10.7
6 12.4	-0.15	-0.06	17.5	-51	----	-23	-148	-----
+17 45	-0.98	-0.40	29	-41	----	0	-117	G104-27
47 G105-B2B	16.58	200(2)		----	-8	+93	-17	-----
6 25.0	+0.21	+0.050		----	-21	-37	-44	+13.2*
+10 02	-0.72	-0.087		----	+1	-1	+2	G105-B2
48 SA26-82	16.70	1	(DA)	----	----	+94	----	+10.8
6 39.6	-0.05	----		----	----	+15	----	-----
+44 43	-0.95	----		----	----	+30	----	L22
49 α CMa B	8.3	----	DA	-14	----	----	-349	+11.1*
6 43.0	(-0.12)*	-0.502	(22)*	0	----	----	-221	ρ = -7.6
-16 39	(-1.03)*	-1.215	(32)	-8	----	----	-474	-----
50 He 3	12.10	60(2)	DAn	+13	----	+96	+78	+11.0*
6 44.3	-0.08	-0.18	28.8	-62	----	+3	-370	-----
+37 36	-0.92	-0.93	40	-40	----	+27	-241	L23
51 G87-29	15.64	200(5)	4670	----	+17	+94	+61	-----
7 06.9	+0.30	-0.29		----	-25	0	-91	+13.4*
+37 45	-0.55	-0.31		----	-50	+34	-169	G87-29
52 G107-70	14.62	200(3)	DC	----	+21	+88	+213	-----
7 27.1	+0.99	-0.26		----	-56	+16	-555	+14.6:*
+48 17	+0.40	-1.32		----	-23	+44	-231	G107-70
53 α CMi B	10.7	----		----	-5	----	-60	ρ = -3.2
7 36.7	----	+0.708		----	-9	----	-301	+13.0
+5 21	----	-1.030		----	-18	----	-505	-----
54 L745-46A	12.98	100(2)	DF*	----	-32	+59	-398	-----
7 38.0	+0.29	+1.136	5.8	----	-22	-81	-271	+13.5*
-17 17	-0.61	-0.520	10	----	+28	+4	+345	L25
55 NGC2477-116	13.66	74(4)		-8	----	+28	-19	+10.7
7 49.8	-0.13	+0.055		-3	----	-95	-8	-----
-38 21	-0.95	-0.018		+7	----	-10	+18	*
56 L97-12	14.5	----	DC*	----	-184	-17	-919	-----
7 52.8	+0.4:	+1.45		----	+11	-93	+53	+13.0:
-67 38	----	-1.45		----	+62	-33	+311	L26
57 L817-13	13.56	1	DA	-20	-10	+59	-61	+10.9
7 52.8	-0.02	-0.13	28.4	-21	-11	-80	-64	+12.2
-14 38	-0.79	-0.2[illegible]	43	-41	-20	+12	-122	-----
58 G111-71	16.58	100(2)	DA,F?	----	+28	+84	+60	-----
8 16.7	+0.36	-0.20	9.3	----	-45	-4	-135	+13.2*
+38 44	-0.58	-0.32	20	----	-48	+55	-101	G111-71
59 LB390*	17.85	200(3)		----	+36	----	+8	ρ = +33.0
8 36.9	+0.16	-0.034		----	-17	----	-3	+12.2*
+20 11	-0.68	-0.011		----	0	----	-14	*
60 LB1847*	18.23	200(3)		----	+33	----	+6	ρ = +33
8 36.9	+0.05	-0.025		----	-19	----	-5	+12.6*
+19 57	-0.49	-0.013		----	+4	----	-11	*
61 LB393*	17.66	200(3)		----	+37	----	+9	ρ = +33
8 37.6	+0.04	-0.036		----	-19	----	-4	+12.1*
+19 54	-0.60	-0.014		----	-2	----	-15	*
62 L532-81	12^{m}70	----	DA,Fs?	---	+77	+26	+77	-----
8 39.7	----	-1$''$06	16.0	----	+21	-96	+21	+12.0*
-32 47	----	+1$''$31	17	----	-16	+10	-16	L28
63 LDS235B	15^{m}55	200(2)	DB	+19	----	+42	+20	+10.7*
8 45.3	-0.06	-0$''$12	9.1	-8	----	-87	-8	-----
-18 48	-0.93	-0$''$05	18	-56	----	+26	-58	L29
64 G116-16	15.32	200(2)	DAs	-44	----	+72	-6	+11.7*
9 13.4	+0.24	+0.03	19.5	-58	----	+4	-132	ρ = -57
+44 12	-0.53	-0.28	22	-34	----	+70	+14	G116-16
65 G117-B15A	15.52	100(3)	DA	----	+12	+69	+47	-----
9 21.2	+0.20	-0.14	(36)	----	-2	-11	-9	+13.4:*
+35 30	-0.56	-0.02	(53)	----	-12	+71	-47	G117-B15
66 LDS275AB	15.0	----	DC	----	+42	+8	+170	-----
9 35.0	----	-0.34		----	+1	-98	+3	+13.0:
-37 07	----	+0.16		----	-13	+19	-52	L31
67 SA29-130	13.32	1	DA	+2	+1	+65	+6	+11.2
9 43.5	+0.07	0.00	39.3	+36	+21	+4	+137	+12.4
+44 08	-0.54	+0.29	45	-3	-2	+76	-13	L32
68 G117-B11B	17.24	200(2)		----	-27	+63	-438	-----
9 43.5	+0.40	+0.10		----	-26	-15	-422	+13.3*
+33 05	-0.51	-0.10		----	+17	+76	+280	G117-B11
69 G49-33	15.09	100(2)	DA	+25	+11	+56	+46	+11.4
9 55.0	+0.25	-0.23	15.6	-78	-36	-28	-149	+13.2
+24 47	-0.54	-0.30	20	-40	-21	+78	-88	G49-33
70 L825-14	12.97	200(2)	DAn	+34	----	+16	+112	+10.6
10 31.4	-0.15	-0.32	17.1	-16	----	-76	-51	-----
-11 29	-1.02	-0.06	33	-28	----	+63	-92	-----
71 F34	11.12	*	DO:*	-3	----	+52	-155	+10.0
10 36.7	-0.30	+0.034	3.3	-1	----	+6	-71	-----
+43 22	-1.35	-0.024	9	+16	----	+85	+99	F34
72 G44-32	16.55	200(3)		-120	-53	+35	+112	+11.4
10 39.2	+0.29	+0.15		-101	-43	-41	-94	+13.2
+14 32	-0.58	-0.27		+1	+1	+84	+1	G44-32
73 Ton 547	15.40	100(1)	DA	----	----	----	----	+11.3
10 46.8	+0.16	----	36.6	----	----	----	----	+12.6
+28 20	-0.58	----	47	----	----	----	----	Ton 547
74 L898-25	14.28	200(3)	DA	+130	+56	+12	+341	+11.4
10 55.1	+0.32	-0.80		-34	-15	-69	-90	+13.2
-7 15	-0.51	+0.07		-54	-24	+72	-142	L34
75 LB253	13.80	200(2)	DAn	+26	+14	+49	+68	+10.9
11 04.8	-0.02	-0.19	32.1	-38	-21	+36	-100	+12.2
+60 13	-0.81	-0.17	51	+2	+1	+80	+2	-----
76 L970-30	12.92	100(3)	DA	+39	----	+10	+176	+11.2*
11 05.5	+0.09	-0.43	35.1	-16	----	-65	-66	-----
-4 53	-0.69	0.00	56	-20	----	+76	-79	-----
77 Ton 573	15.0:	----	DB	-74	----	+34	-74	+10.0:
11 07.3	----	+0.108	5.9	-57	----	-19	-57	-----
+26 37	----	-0.167	13	+15	----	+92	+15	Ton 573
78 L971-14	15.30	200(3)	DC?*	+193	+103	+8	+264	+11.0
11 15.8	+0.09	-0.50		+2	+1	-61	+2	+12.6
-2 58	-0.76	+0.25		-17	-9	+79	-24	G10-11
79 R627	14.24	1	DF	----	+46	+25	+392	-----
11 21.7	+0.31	-0.95	5.6	----	-19	-25	-163	+13.8*
+21 39	-0.52	0.00	10	----	-18	+94	-149	L36
80 F43	14.89	100(2)	DA	+18	----	+35	+24	+10.6
11 26.5	-0.13	-0.078	21.4	-26	----	+3	-35	-----
+38 28	-1.00	-0.049	33	-6	----	+94	-8	F43
81 F46	13.24	100(2)	DO-B	+12	----	+15	+32	+10.4
11 34.9	-0.30	-0.054	5.6*	+3	----	-34	+8	-----
+14 27	-1.13	+0.044	3.6*	-1	----	+93	-2	F46
82 L145-141	11.44	74(2)	4670*	----	-55	-44	-1136	-----
11 42.9	+0.19	+2.66		----	+26	-90	+544	+13.0*
-64 34	-0.59	-0.33		----	+8	-5	+167	L37
83 G148-7	13^{m}60	100(3)	DAn	-2	----	+25	-5	+11.0*
11 43.4	+0.06	-0$''$11	39.9	-45	----	-5	-134	-----
+32 06	-0.67	-0$''$26	59	-2	----	+97	-5	G148-7

TABLE 1—*Continued*

I	II	III	IV	V	VI	VII	VIII	IX
84 L1405-40B 11 47.7 +25 35	15^{m}55 +0.23 -0.58	100(4) -0″31 -0″07	DA 31.8 35	---- ---- ----	+57 -37 -15	+19 -14 +97	+114 -91 -36	----- +12.4:* L38
85 L1261-24 11 54.2 +18 39	15.54 +0.30 -0.60	200(2) -0.31 +0.02	DC:	+90 -37 -19	+41 -17 -9	+11 -24 +96	+133 -55 -29	+11.4 +13.1 G57-29
86 HZ21 12 11.4 +33 12	14.22 -0.36 -1.25	100(1) -0.096 +0.042	DO 0.8 14	+31 -3 -5	---- ---- ----	+17 +1 +98	+49 -4 -8	+10.2 ----- -----
87 C1 12 13.3 +52 47	13.34 +0.53 -0.48	200(2) -0.054 -0.111	(DA)*	---- ---- ----	0 -5 +2	+31 +31 +90	+2 -55 +19	----- +13.7 -----
88 L1046-18B* 12 14.3 +03 14	14.9 ---- ----	---- -0.64 +0.28	DAs (12) (42)	---- ---- ----	+113 -14 +4	-9 -42 +90	+328 -44 +14	----- +12.5: G13-26
89 G148-B4B 12 15.0 +32 22	16.95 +0.38 -0.46	200(1) -0.16 -0.10		---- ---- ----	+23 -42 -3	+15 +1 +99	+43 -78 -6	----- +13.3* G148-B4
90 HZ28 12 30.0 +41 46	15.72 -0.04 -0.82	1 -0.124 +0.015	DA 25.3 40	+49 -22 -6	+29 -13 -3	+19 +18 +97	+54 -24 -6	+10.9 +12.0 -----
91 HZ29 12 32.4 +37 55	14.18 -0.23 -1.01	1 +0.037 +0.028	DBp* 5.1 52	-4 +11 -1	---- ---- ----	+15 +12 +98	-8 +20 -1	+10.6 ----- -----
92 G61-17 12 44.7 +14 59	15.86 +0.22 -0.53	200(3) -0.38 +0.22	DAs* 43.0 41	+160 -9 +15	---- ---- ----	-10 -19 +98	+207 -11 +19	+11.4* ----- G61-17
93 HZ34 12 53.0 +37 49	15.66 -0.28 -1.26	200(2) -0.034 -0.051	DOp 4.1 16	0 -57 +9	---- ---- ----	+9 +16 +98	0 -29 +5	+10.3 ----- -----
94 L1408-19 12 57.5 +27 50	15.40 +0.28 -0.58	100(2) -0.29 +0.10	DAs 14.1 18	+88 -24 +3	+38 -10 +1	-2 +2 +99	+140 -38 +4	+11.4 +13.3 G149-28
95 W457 12 57.7 +3 46	15.90 +0.64 -0.09	2 -0.45 -0.92	DC	---- ---- ----	-5 -57 -21	-25 -32 +92	-42 -454 -168	----- +15.4* G60-54
96 G14-24* 12 59.5 -1 49	12.78 +0.75 0.00	100(2) +0.02 -0.47	sdK ?* 8.5 8	+236* -324 -44	-62 -79 +123	-30 -38 +87	-113 -158 -109	ρ = +156 +12.2* G14-24
97 HZ39 13 02.4 +28 28	15.44 -0.32 -1.16	200(2) +0.005 -0.008	DAs 5.4 13	-4 -2 0	---- ---- ----	-4 +4 +99	-4 -2 0	+10.4 ----- -----
98 HZ43 13 14.0 +29 22	12.86 -0.10 -1.14	1 -0.149 -0.088	DAwk 9.2 37	+10 -25 +2	---- ---- ----	-6 +8 +99	+32 -75 +8	+10.3 ----- -----
99 W485A 13 27.7 -8 21	12.30 +0.08 -0.61	100(3) -1.077 -0.462	DA 31.9 45	+56 -84 -9	---- ---- ----	-45 -39 +80	+308 -459 -51	+11.0* ----- L47
100 W489 13 34.3 +3 58	14.68 +0.96 +0.37	1 -3.750 -1.220	DK* 2.2 19	---- ---- ----	+81 -114 +8	-38 -22 +90	+1078 -1524 +79	----- +15.3* L49
101 LDS455A 13 34.3 -16 04	15.35 -0.06 -0.83	100(2) -0.086 -0.026	(DA)? (10)	---- ---- ----	+13 -16 -1	-53 -47 +71	+27 -33 -1	----- +11.9* L50
102 Gw70°5824 13 37.8 +70 33	12.79 -0.09 -0.84	1 -0.40 -0.02	DA 35.2 55	+35 -30 +10	---- ---- ----	+32 +61 +72	+140 -121 +42	+10.8 ----- L52
103 AC58°43662 13 40.6 +57 15	16.73 +0.55 -0.27	200(1) -0.200 +0.220	(DA)*	+162 +7 -37	+68 +3 -16	+17 +49 +86	+137 +6 -31	+11.4 +13.2 -----
104 L619-50 13 48.1 -27 18	15^{m}0: +0.1: ----	---- +0″06 -0″22	(DA)*	---- ---- ----	0 -19 -19	-63 -55 +55	-1 -76 -77	----- +13.0: L53
105 LP439-354 14 09.5 +15 47	18^{m}12 +0.96 +0.30	200(2) -0″68 0″00		---- ---- ----	-87 -80 -38	-37 +4 +93	-226 -208 -99	----- +15.2 -----
106 LP439-356 14 11.5 +15 44	16.20 +0.07 -0.65	200(4) -0.28 0.00	DA 33.8 43	+92 -86 +42	+51 -47 +23	-38 +4 +92	+92 -86 +42	+11.2 +12.5 G135-29
107 F93 14 15.3 +13 16	15.33 -0.23 -1.12	200(2) ---- ----	DAwk 10.0 25	---- ---- ----	---- ---- ----	---- ---- ----	---- ---- ----	+10.5 ----- F93
108 Ton 197 14 21.5 +31 50	15.30 -0.12 -1.00	100(1) ---- ----	DAwk 24.1 41	---- ---- ----	---- ---- ----	---- ---- ----	---- ---- ----	+10.7 ----- Ton 197
109 Ton 202 14 25.3 +26 46	15.68 +0.20 -0.73	100(1) ---- ----	DC*	---- ---- ----	---- ---- ----	---- ---- ----	---- ---- ----	+11.2 +12.3 Ton 202
110 L19-2 14 25.4 -81 07	13.0: 0.0: ----	---- -0.21 -0.40	(DA)* (28)	+40 -15 -3	---- ---- ----	-57 -76 -33	+159 -63 -129	+11.0: ----- L54
111 L1126-68 14 48.4 +7 47	15.47 +0.02 -0.67	1 -0.84 -0.41	DA 33.3 46	+96 -304 +80	+52 -164 +43	-56 +4 +83	+130 -410 +108	+11.1 +12.5 G66-36
112 LP135-155 15 10.6 +56 37	16.24 +0.23 -0.60	200(3) ---- ----		---- ---- ----	---- ---- ----	---- ---- ----	---- ---- ----	+11.5:* ----- -----
113 +1°3129B 15 44.2 +00 53	15.27 -0.32 -1.19	100(2) ---- ----	DAwk 9.6 13	---- ---- ----	---- ---- ----	---- ---- ----	---- ---- ----	+10.0* ----- BD
114 -37°6571B 15 44.2 -37 45	12.80 +0.30: -0.40:	74(2) -0.432 -0.220	DAs* 29.0 39	+16 -26 +5	---- ---- ----	---- ---- ----	+97 -203 +47	+12.0* ρ = -4 L60
115 R808 15 59.6 +36 58	14.36 +0.17 -0.56	2 +0.13 -0.56	DA 30.6 40	-103 -39 -17	-51 -19 -9	-34 +56 +75	-252 -95 -42	+11.3 +12.8 L61
116 C2 16 06.7 +42 13	13.85 +0.06 -0.54	200(2) ---- ----	DA 31.2 38	---- ---- ----	---- ---- ----	---- ---- ----	---- ---- ----	+11.2 +12.6 *
117 G138-8 16 09.1 +13 30	15.10 +0.23 -0.65	200(1) -0.59 0.00	DAs 21.8 27	+58 -109 +115	+29 -54 +57	-69 +34 +66	+97 -180 +190	+11.2 +12.7 G138-8
118 L770-3 16 15.1 -15 28	12.40 -0.25 -1.02	60(1) -0.17 -0.18	DAwk 18.7 35	+1 -29 +1	---- ---- ----	-91 -2 +41	+5 -117 +6	+10.5 ----- G153-41
119 R640 16 26.8 +36 51	13.86 +0.18 -0.68	100(2) -0.46 +0.74	DFp* 20 18	+131 +9 +63	+56 +4 +27	-37 +62 +70	+372 +26 +178	+11.1 +12.8 L62
120 L1491-27 16 37.4 +33 32	14.64 +0.22 -0.58	1 -0.04 -0.43	DAs 25.3 26	-79 -50 -5	-37 -24 -2	-43 +62 +66	-172 -110 -105	+11.3 +13.0 -----
121 Ton 261 16 44.5 +26 43	16.15 -0.26 -0.97	100(1) ---- ----	DOp* 3.3 14	---- ---- ----	---- ---- ----	---- ---- ----	---- ---- ----	+10.6 ----- Ton 261
122 L845-70 17 08.5 -14 45	14.30 +0.02 -0.68	100(2) +0.27 -0.24	DC?*	-27 -9 -103	-13 -4 -46	-96 +13 +25	-45 -17 -164	+10.3 +12.0 L66
123 W672B 17 16.2 +2 01	14.26 +0.13 -0.59	100(5) -0.42 -0.31	DA 37.0 48	---- ---- ----	-14 -56 +24	-85 +37 +37	-56 -221 +97	----- +12.2* G19-20
124 G140-B1B 17 50.5 +9 49	15.72 +0.10 -0.78	200(2) 0.00 -0.10	DC:	---- ---- ----	-12 -12 -8	-80 +55 +30	-30 -31 -20	----- +12.7* G140-B1
125 R137 18 24.8 +4 02	13^{m}90 +0.05 -0.55	100(2) -0″25 -0″30	DA 35.8 45	-33 -54 +14	-15 -24 +6	-82 +55 +13	-96 -153 +40	+11.2 +12.8 G21-15

TABLE 1—*Continued*

I	II	III	IV	V	VI	VII	VIII	IX
126								
L993-18	$14^{m}54$	100(3)	DAs	-27	-13	-89	-57	+11.2
18 26.5	+0.24	$0''00$	14.7	-52	-25	+44	-108	+12.8
-4 31	-0.56	$-0''29$	23	-32	-15	+5	-64	G21-16
127								
L1498-127	14.64	200(1)	DAn	+71	+34	-42	+145	+11.2
18 55.7	+0.17	+0.04	47.9	+28	+14	+88	+57	+12.8
+33 52	-0.60	+0.34	51	+23	+11	+23	+47	-----
128								
G141-54	15.52	200(3)	DAs	----	----	----	----	+11.3
18 57.5	+0.20		26.6	----	----	----	----	+12.9
+11 54	-0.57		26	----	----	----	----	G141-54
129								
Gw70°8247	13.19	1		----	+36	+18	+240	-----
19 00.6	+0.05	+0.101	4135*	----	-7	+89	-51	+12.3*
+70 36	-0.85	+0.508		----	+1	+42	+5	L73
130								
G142-B2B	14.00	200(2)	DAn	-11	----	-67	-31	+11.5*
19 11.3	+0.12	0.00	45.3	-10	----	+74	-28	-----
+13 31	-0.60	-0.10	62	-8	----	+2	-22	G142-B2
131								
LDS678B	12.24	100(4)	DAwk	----	-4	-86	-44	-----
19 17.9	+0.07	-0.06	2.3	----	-7	+48	-82	+12.6*
-7 45	-0.84	-0.19	28	----	-1	-17	-15	L74
132								
LDS683B	15.95	100(2)	DA	----	-22	-87	-23	-----
19 32.9	+0.05	-0.02	35.5	----	-56	+42	-60	+11.1*
-13 36	-0.76	-0.14	52	----	-17	-27	-18	L75
133								
L1573-31	14.51	1	DB	-43	----	-31	-75	+10.7
19 40.4	-0.09	+0.02	10.9	-10	----	+94	-18	-----
+37 24	-0.97	-0.20	19	-32	----	+12	-56	-----
134								
G142-50	14.08	200(2)	DA	-36	-22	-61	-84	+10.9
19 43.3	-0.06	0.00	28.4	-29	-18	+79	-67	+12.0
+16 20	-0.86	-0.26	44	-26	-16	-4	-61	G142-50
135								
L997-21	13.69	100(2)	DAs	----	-34	-74	-259	-----
19 54.0	+0.25	-0.46	12	----	-40	+62	-299	+13.1*
-1 09	-0.60	-0.70	21	----	+5	-26	+35	L79
136								
WZ Sge	15.2v	100(2)	DAep*	+26	----	-53	+14	+11.0
20 05.3	+0.10	+0.077	27.1	-23	----	+84	+3	ϱ = -30
+17 33	-0.72	-0.014	119	-20	----	-14	-34	-----
137								
L710-30	14.2	----	DA	----	+1	-84	+7	-----
20 07.3	----	+0.12	21.4	----	-18	+32	-104	+13.0:
-21 55	----	-0.26	22	----	-15	-45	-86	L80
138								
G24-9	15.67	200(3)	DC?*	----	-45	-64	-248	-----
20 11.8	+0.40	-0.31		----	-41	+73	-227	+14.3*
+6 34	-0.44	-0.64		----	-49	-26	-275	G24-9
139								
W1346	11.54	1	DA	+42	----	-38	-297	+10.8*
20 32.3	-0.07	-0.40	27.0	-18	----	+91	-125	-----
+24 53	-0.87	-0.55	37	0	----	-16	0	L82
140								
L116-79	13.25	Bell	(DA)*	+25	----	-68	+86	+10.9
20 30.6	-0.06	+0.17	(30)	-22	----	-45	-73	-----
-68 16	-0.81	-0.19		-13	----	-58	-44	-----
141								
L711-10	12.0	----	DA	----	+8	-76	+82	-----
20 39.7	----	+0.32	26.3	----	-3	+36	-26	+12.0:
-20 16	----	-0.09	40	----	-13	-55	-132	-----
142								
L24-52	13.50	Bell	(DA)*	+28	+14	-56	+109	+11.4
21 05.2	+0.27	+0.08	(47)	-34	-16	-65	-130	+13.0
-82 01	-0.59	-0.36		+12	+6	-52	+44	L83
143								
R198	14.66	2	(DA)	+72	+35	+11	+140	+11.1
21 24.8	+0.15	+0.20	(52)	-8	-4	+99	-16	+12.5
+54 59	-0.68	+0.22		+4	+2	+6	+10	L85
144								
Gw73°8031	12.88	1	DA	-17	-9	+32	-74	+11.1
21 26.6	+0.01	+0.045	37	+14	+7	+90	+62	+12.5
+73 25	-0.66	-0.310	58	-27	-14	+28	-113	L86
145								
LDS749B	$14^{m}73$	100(3)	DB*	----	+94	-48	+146	ϱ = -78
21 29.6	-0.07	$+0''420$	5.0	----	-55	+66	-11	+12.0
+0 00	-0.92	$0''000$	11	----	-3	-57	-135	G26-10
146								
L1002-62	$14^{m}0$	----	DB	+15	----	-51	+30	+10.5
21 31.0	----	$+0''090$	14.2	-2	----	+60	-5	-----
-4 46	----	$-0''006$	23	-15	----	-61	-30	-----
147								
Gw82°3818	13.02	1	DA	+62	+31	+42	+246	+11.0
21 36.7	-0.02	+0.31	24.4	-40	-20	+82	-161	+12.5
+82 49	-0.72	+0.56	40	+19	+9	+38	+74	L88
148								
L1363-3	13.23	100(3)	DC*	-77	-44	-24	-276	+10.9
21 40.3	+0.17	-0.24		-38	-21	+88	-134	+12.2
+20 45	-0.72	-0.66		-36	-20	-40	-127	G126-27
149								
L930-80	14.80	100(1)	DB	+33	----	-49	+80	+10.7
21 44.9	-0.06	+0.31	10.8	-32	----	+55	-78	-----
-7 58	-0.96	-0.16	11	-50	----	-67	-121	G26-31
150								
G93-48	12.77	60(2)	DA	-18	-11	-39	-78	+11.0
21 49.9	0.00	0.00	27.4	-25	-16	+68	-112	+12.0
+2 09	-0.78	-0.33	38	-17	-11	-61	-76	G93-48
151								
L1003-16	14.41	200(1)	DAs	-25	-9	-42	-62	+11.4
21 51.5	+0.26	0.000	23.8	-40	-15	+64	-99	+13.5
-1 31	-0.51	-0.275	27	-23	-9	-65	-58	G93-53
152								
LDS766A	14.0	----	(DA)*	+21	----	-62	+42	+10.5:
21 54.9	----	+0.13		-46	----	-4	-92	-----
-43 42	----	-0.18		-14	----	-78	-28	L90
153								
LDS785A	14.5	----	DB	+51	----	-51	+80	+10.5:
22 24.6	----	+0.21	14.0	-17	----	+10	-28	-----
-34 27	----	-0.02	30	-30	----	-85	-52	L92
154								
G28-13	16.21	200(1)	DA,Fs*	-119	-43	-25	-132	+11.4
22 40.5	+0.31	-0.16	15.8	-80	-16	+59	-89	+13.5
-1 43	-0.60	-0.30	28	-23	-9	-77	-26	G28-13
155								
G67-23	14.35	100(2)	DA	+65	+46	-1	+214	+11.0
22 46.6	+0.20	+0.51	38.1	-17	-12	+85	-58	+12.7
+22 20	-0.70	+0.04	39	-29	-21	-53	-97	G67-23
156								
G28-27	17.2:	100(3)	4670:			-11	-138	Table
22 54.9	+0.1:	-0.20				+69	-47	5
+7 40	-1.0:	-0.24				-71	-24	G28-27
157								
F108	12.90	100(1)	DAs:	-8	----	-13	-25	+10.5
23 13.6	-0.28	-0.054	7.4	+1	----	+55	+5	-----
-2 07	-1.06	-0.011	11	+2	----	-83	+7	F108
158								
F110	11.50	60(1)	DOp*	+1	----	-14	+1	+10.4
23 17.4	-0.30	+0.003	4.7	-2	----	+49	-2	
-5 26	-1.20	-0.003	10	-1	----	-86	-1	F110
159								
G29-38	13.10	100(2)	DA	-63	-35	-2	-264	+11.2
23 23.6	+0.20	-0.47	44.4	-4	-2	+62	-16	+12.5
+4 58	-0.65	-0.30	43	-1	-1	-79	-6	G29-38
160								
C3	13.82	200(1)	DAn	----	----	----	----	+11.0
23 29.2	+0.03	----	40.5	----	----	----	----	+12.6
+40 45	-0.72	----	57	----	----	----	----	*
161								
G128-72	15.25	200(1)	DAn	+127	+62	+17	+200	+11.2
23 29.5	+0.22	+0.47	26.5	-51	-25	+82	-80	+12.8
+26 42	-0.58	+0.02	52	-37	-18	-54	-58	G128-72
162								
L1512-34B	12.90	200(3)	DA	----	-13	+25	-107	-----
23 41.4	+0.15	-0.23	39.6	----	+4	+84	+35	+12.4*
+32 15	-0.61	-0.06	56	----	+1	-47	+5	L93
163								
LDS826A	14.6	----	(DAs)*	----	-54	-24	-204	-----
23 51.5	----	-0.30		----	-29	+1	-110	+12.5:
-33 33	----	-0.40		----	+13	-97	+49	L94
164								
L505-42	14.7	----	(DA)*	----	-33	-26	-122	-----
23 51.7	----	+0.02		----	-81	-4	-295	+12.5:
-36 50	----	-0.68		----	+13	-96	+45	L95
165								
L362-81	$13^{m}05$	Bell	(DAs)*	----	+10	-28	+122	-----
23 59.6	+0.07	$+0''60$	(14)	----	-35	-15	-407	+13.4*
-43 25	-0.87	$-0''67$		----	+3	-95	+29	L96

NOTES TO TABLE 1

1. G130-49.—M_V from Table 3.
3. LB433.—He I very strong.
5. VMa 2.—Strong metallic lines in ultraviolet. See Weidemann (1960). M_V from trigonometric parallax.
11. L870-2.—M_V from trigonometric parallax.
12. G34-49.—M_V from Table 3.
14. G71-B5B.—M_V from Table 3.
18 G94-B5B.—M_V from Table 3.
20. F24.—Relatively sharp and weak H emission lines (Hα to Hζ) superposed on broad absorption. Also Ca II emission. Perhaps an old nova. One plate shows weak λ 4686, He II absorption.
21a. LB3303.—Has red companion, visual mag. 14.8″ distant. Spectra by Thackeray (1961)
24. W219.—M_V from trigonometric parallax.
25. LB1497.—Pleiades cluster (Luyten and Herbig 1960). Cluster velocity of +5 km/sec has been assumed.
26. HZ4.—The values of M_V for the Hyades cluster members HZ4, LB227, HZ10, HZ2, HG7-138, VR7, VR16, HZ7, and HZ14 all assume a modulus of $V_E - M_V = 3.00^m$. The values of the radial velocity are those expected of members.
27. G7-17.—The spectrum is very peculiar and bears some resemblance to that of G95-59 (see text). Ca II is sharp and weak, Ca I broad and weak. Blends of Fe *I* lines are seen in the *UV*. This could be a sdMp without metals and TiO bands. As discussed in Section IV, this object shares the proper motion of W219 and the value of M_V is obtained from the assumption that it belongs to the W219 group.
28. LB1240.—On the near side of the Hyades cluster; $V_E - M_V = 1.50^m$.
32. HG7-138.—The spectrum is peculiar. Ca II is very sharp and very weak Blended Fe I lines are suspected in the *UV*. If this is not a white dwarf it could be an extremely weak-lined sdK.
33. 40 Eri B.—M_V from trigonometric parallax. Radial velocity from *A* component. Triple system. Oke (unpublished) obtains $W(\mathrm{H}\gamma) = 42$ Å from spectrum scans.
38. HZ9.—H, Ca II, and Si I emission. Probably an unresolved double of DA and dMe types; Na I absorption may appear in the red.
40. G39-27.—M_V from Table 3. The radial velocity is from one 200-inch coudé plate of the companion, G39-28, which is a peculiar, emission-line star of type K. The system is an outlying member of the Hyades cluster, only 16 pc from the Sun.
41. L879-14.—Typical λ 4670 star with C_2(0, 0) and (1, 0) broad featureless bands. Probably a member of W219 group (Sec. VII).
43. G86-B1B.—M_V from Table 3. Emission lines from IC410 superposed.
44. G102-39.—M_V from Table 3. The radial velocity is from the companion, GC7413.
45. LP658-2.—M_V from trigonometric parallax. The spectrum shows only very weak and sharp Ca II lines plus emission lines superposed from the Orion Nebula. Similar to No. 54 (L745-46A).
47. G105-B2B.—M_V from Table 3.
49. α CMa B.—The values of $B - V$ and $U - B$ were estimated from high dispersion spectra and Hγ line profiles by Greenstein and Oke (unpublished). M_V from trigonometric parallax. The radial velocity is from the A component.
50. He3.—M_V from trigonometric parallax. A radial velocity determination from two McDonald plates is +80 km/sec.
51. G87-29.—M_V from Table 3. λ 4670 band is weak.
52. G107-70.—M_V from Table 3. No lines visible from violet to λ 6700.
53. α CMi B.—Radial velocity from A component. M_V from trigonometric parallax.
54. L745-46A.—M_V from trigonometric parallax. The cpm companion is at present too close to a field star for photometry. The spectrum shows sharp, weak Ca II but no other lines; no Fe I lines in *UV*.
55. NGC2477-116.—Chart by Eggen and Stoy (1961).
56. L97-12.—Spectrum by Bell (1962).
58. G111-71.—M_V from Table 3. Spectra poor; Ca II lines very weak if present.
59, 60, 61. LB390, 1847, and 393.—Members of the Praesepe cluster (Luyten 1962). The mean radial velocity of the main-sequence cluster members is adopted. The modulus is $V_E - M_V = 5.55^m$. Finding charts are given by Luyten (1962).
62. L532-81.—M_V from trigonometric parallax; 0.110″ Y(10) and 0.105″ C(8). Possibly very weak Ca II present in the spectrum.
63. LDS235B.—M_V from Table 3. He I is very strong and relatively sharp.
64. G116-16.—M_V from Table 3. The radial velocity of this star, from one plate, is +80 km/sec. The radial velocity of −57 km/sec used to compute the values of (*UVW*) is from one good plate of the companion.
65. G117-B15A.—M_V from Table 3.
66. LDS275AB.—Double white dwarf with 4″ separation. Spectra of the system, and of the *A* component alone, are nearly continuous.
68. G117-B11B.—M_V from Table 3.
71. F34.—Photometric results are by Sandage (unpublished). Spectrum is peculiar and may be that of a subdwarf of type O.
76. L970-30.—M_V from Table 3.
78. L971-14.—Spectrum may be composite and not that of a white dwarf. Very weak traces of Hγ, the G-band, and sharp Ca II on a very blue continuum. This star may be a binary like SS Cyg. The high

U-velocity indicates that if this is an sdO with a red companion, both are of low luminosity. The color is similar to that of WZ Sge (No. 136).

79. R627.—M_V from trigonometric parallax.

81 F46.—Could be sdO. The equivalent widths are for Hγ and λ 4472.

82. L145-141.—M_V from trigonometric parallax. A probable member of W219 group (Sec. VII). Spectral type by Bell (1962).

83. G148-7.—M_V from Table 3. The red companion has a peculiar spectrum with weak TiO bands.

84. L1405-40B.—M_V from Table 3. The A component has an ultraviolet deficiency with respect to the Hyades stars, but its spectrum shows H emission and weak TiO bands.

86. HZ21.—Very hot; He II, He I, and H weak. Could be extreme sdO.

87. C1.—Spectral type by Stephenson (1960).

88. L1046-18B.—Cpm companion too close for photometry.

89. G148-B4B.—M_V from Table 3.

91. HZ29.—Very shallow (double?) He I lines.

92. G61-17.—M_V from Table 3. Companion has weak TiO bands. A third star is 3″, 240°.

93. HZ34.—Spectrum could be that of an extremely hot sdO. Lines are very shallow.

95. W457.—M_V from trigonometric parallax.

96. G14-24.—Spectrum is that of a very weak-line, late-type subdwarf. The trigonometric parallax of 0.074″ C(8) indicates the star is degenerate. The values of (*UVW*) in Column V are based on the assumption that the star is a subdwarf (π = 0.006″) whereas those in Column VI are based on the trigonometric parallax.

98. HZ43.—Has a close, faint companion of type dM which is possibly variable. Not resolved photometrically.

99. W485A.—M_V from Table 3. $M_V = +10.8^m$ from trigonometric parallax.

100. W489.—M_V from trigonometric parallax. Ca II possible, weak and shallow.

101. LDS455A.—M_V from Table 3.

103 AC58°43662.—Spectral type by Stephenson (1960).

104. L619-50.—Spectral type by Luyten (1952).

109. Ton 202.—Spectrum may resemble that of an old nova with very weak absorption and emission lines.

110. L19-2.—Spectral type by Bell (1962).

112. LP135-155.—M_V from Table 3.

113. 1°3129B.—M_V from Table 3. Very blue for type.

114. −37°6571B.—M_V from Table 3. Radial velocity from A component. $M_V = +12.0^m$ from trigonometric parallax. Spectral type by Luyten (1952).

116 C2.—Chart by Stephenson (1962).

119. R640.—Ca II and Mg I lines only; no H lines in spite of blue color.

121. Ton 261.—Either DO or faint sdO.

122. L845-70.—Possibly a λ 4670 star.

123. W672B.—M_V from Table 3.

124. G140-B1B.—M_V from Table 3.

129. Gw 70°8247.—M_V from trigonometric parallax. Spectrum unique in the presence of unidentified λ 4135 bands.

130 G142-B2B.—M_V from Table 3.

131. LDS678B.—M_V from Table 3. M_V is also $+12.6^m$ from the trigonometric parallax.

132. LDS683B.—M_V from Table 3.

135. L997-21.—M_V from trigonometric parallax.

136 WZ Sge.—Nova Sge (1913, 1946). Spectral features and luminosity by Greenstein (1957). Systematic velocity = −30 km/sec (Kraft 1964). Chart by Humason (1938).

138. G24-9.—M_V from Table 3. Too faint to establish DC nature with certainty.

139 W1346.—M_V from trigonometric parallax.

140. L116-79.—Spectral type by Bell (1962).

142. L24-52.—Spectral type by Bell (1962).

145 LDS749B.—M_V from Table 3. Radial velocity from A component. He I lines sharp.

148 L1363-3.—The six available spectra show that no lines are visible from Hα to λ 3300.

152 LDS766A.—Spectral type by Luyten (1952). A cpm companion of M type is 19″ distant.

153 LDS785A.—A cpm companion of late type is 9″ distant.

154 G28-13 —Spectrum has very weak Ca II lines.

156. G28-27.—Weak C_2 bands seem to be present. Possibly composite, DK + DA(?). H- and K-lines very shallow, Hβ and Hγ absorption suspected. Possibly variable. Photometry and spectroscopy being continued. Possible member of the W219 group (Sec. VII).

157. F108 —Could be a peculiar, hot subdwarf; only H visible.

158. F110 —Could be a peculiar, hot subdwarf. He II lines are very strong and sharp and the H lines are sharp. In spite of the similarity in color, the spectrum does not resemble that of F108 (No. 157).

160. C3 —Finding chart (Stephenson 1962).

162 L1512.-34B —M_V from Table 3.

163 LDS826A.—A cpm companion of late type is 7″ distant. Spectral type by Luyten (1952).

164 L505-42.—Spectral type by Luyten (1952).

165 L362-81 —Spectral type by Bell (1962). M_V from trigonometric parallax.

the new measurements, the size of the telescope in inches is followed, in parentheses, by the number of observations; two stars were observed with the 74-inch reflector at Pretoria. The remaining values are by Harris (1956; indicated by "1"), Johnson (1955; indicated by "2") or by Bell (1962), for a few southern stars. All available proper motions were utilized, including some unpublished values kindly supplied by Giclas or Luyten.

Column IV. Spectral type/$W(H\gamma)/w_{0.5}(H\gamma)$. W = equivalent width in Å and $w_{0.5}$ = width in Å at half-central depth. If the star has no hydrogen lines, $W(K)$ and $w_{0.5}(K)$ are given and for helium-line, DB stars, $W(4472)$ is given instead of $W(K)$. A few spectral types by others, given in parentheses, are acknowledged in the notes to the table; these and uncertain measures are indicated by parentheses or by a colon.

Columns V and VI. The values of (UVW) in km/sec from the proper motions alone, for the two probable luminosities listed in Column IX. Where the radial velocity is available, in a few cases, it was incorporated into the values of (UVW). U is positive in the direction away from the galactic center, V is positive in the direction of galactic rotation, and W is directed toward the north galactic pole.

Column VII. Lines 1, 2, and 3 give the percentages of the radial velocity that should be added, respectively, to (UVW). When a radial velocity is available from a second star in a binary system or from membership in a cluster, it is included in the motions given in columns V and VI, and the radial velocity, labeled ρ, is given in Column IX.

Column VIII. The changes in (UVW) caused by an *increase* of 100 pc in the assumed distance.

Column IX. The first two lines contain visual luminosities derived from the two assumptions discussed in the text. When a luminosity is derived from a trigonometric parallax, or from a second component in a binary or common proper-motion system, or from membership in a cluster (based on proper motion), it is indicated by an asterisk and the origin is given in the notes to the table. The last line contains the source of identification charts; G (*Publications of the Lowell Observatory,* Giclas *et al.* 1962), L (Luyten 1949), F (Feige 1959) and Ton (Chavira 1959).

II. LUMINOSITIES

Accurate luminosities of the white dwarfs have been determined by the use of (1) well-determined trigonometric parallaxes, (2) second components in pairs containing one white dwarf, and (3) stars in galactic clusters. The best available trigonometric parallax determinations for white dwarfs are listed in Table 2 where the parallax values determined at individual observatories, corrected to absolute values by the precepts given by Jenkins (1952), are listed; the observatory abbreviations and the weights, in parentheses, are those given by Jenkins. Only stars with mean trigonometric values greater than 0.05″ are included. Unfortunately accurate magnitudes and colors for two of the nearest objects, the companions to Sirius and Procyon, are not directly available.

Several stars in wide binary systems where photometry of the companion is possible and individual spectra may be obtained are listed in Table 3. Because of selection effects caused by the low luminosity of the white dwarfs, the known companions to such stars are often extremely red and faint, main-sequence objects. In the few cases where the values of $B - V$ for the companions are less than $+0.8^{m}$, the moduli of the systems have been obtained from fitting the companions to the main sequence after correcting for differential blanketing effects (Sandage and Eggen 1959; Wildey, Burbidge, Sandage, and Burbidge 1962). When the companions are redder than $B - V = +0.8^{m}$, the blanketing effects are masked (Sandage and Eggen 1959) and the luminosities derived from photometric parallaxes are therefore uncertain. Furthermore, for stars redder than about $B - V = +1.4^{m}$ the colors are greatly affected by the presence of TiO bands in the spectrum, and the calibration of the $(M_V, B - V)$ relation is uncertain; the $(B - V)$ scale is contracted, and the $B - V$ color is sensitive to the strength of the TiO bands. To

TABLE 2

TRIGONOMETRIC PARALLAXES OF WHITE DWARFS

Name	π	M_V	$U-V$	Table 1
V Ma 2	0″242 A(16) 248 M(7) 243 W(7) 223 S(20) 233 Y(5)	+14 2	+0 60	5
L870-2	61 C(6)	+11 8	−0 16	11
W319	068 W(8)	+14 4	−0 22	24
40 Eri B	210 A(20) 208 M(10) 197 Y(10) 212 V(10) 194 C(7)	+11 0	−0 65	33
LP658-2	147 Ly	+15 4	+1 87	45
He 3	062 M(8) 054 Yk(10) 038 W(8) 067 V(7)	+11 0	−1 00	50
L745-46A	159 C(8) 102 Y(7) 102 V(5)	+13 5	−0 31	54
R627	080 W(6)	+13 8	−0 21	79
L145-141	213 Y(16) 189 C(7)	+13 0	−0 40	82
W457	078 W(8)	+15 4	+0 55	95
G14-24	074 C(8)	+12 2	+0 75	96
W485	048 M(4) 069 C(6) 043 W(3)	+10 8	−0 53	99
W489	131 W(7)	+15 3	+1 33	100
−37°6571	063 Y(10) 078 C(6)	+12 0	−0 10	114
Gw 70°8247	047 Yk(7) 047 W(8) 062 G(7) 109 Lo(3)	+12 3	−0 80	129
LDS678	118 Y(10)	+12 6	−0 77	131
L997-21	076 W(7)	+13 1	−0 35	135
W1346	093 M(7) 075 Yk(8) 052 W(8) 072 S(28)	+10 8	−0 94	139
L326-81	111 L(16) 0 133 C(7)	+13 4	−0 80	165

TABLE 3—WIDE BINARIES CONTAINING A WHITE-DWARF COMPONENT

Name	V_B	$V-R$	$R-I$	N	$B-V$	$U-B$	N	M_V	Sp.	Table 1
G130-50 .	13 21	+0 99	+0 87	2	+1 41	+1 11	3	+ 9 7	.	.
G130-49 . . .	16 85	. . . .	. . . .	.	+0 25	−0 70	3	+13 4	. . . .	1
G34-48	13 13	+0 97	+0 82	3	+1 45	+1 20	3	+ 9 4	sdM3	. .
G34-49. . . .	17 41	. . .	. . . .	.	−0 05	−0 62	2	+13 7	DC	12
G71-B5A . .	14 25	+1 04	+0 905	3	+1 43	+1 09	2	+ 9 9		.
G71-B5B	17.16	.			+0 21	−0 81	1	+12 8	.	14
G94-B5A	8 30		. .		+0 61	+0 10	3	+ 5 0	dG	. .
G94-B5B	15 83	. .	. . . .	.	+0 07	−0.71	3	+12 5	DC	18
G5-27 .	7 41	+0 36	+0 29	2	+0 78	+0 35	4	+ 6 0	(G5)	. .
G5-28. .	15 54	. . .	. . .	.	+1 32	+0 38	4	+14 1	DMp	21b
G39-28 .	8 42	+0 58	+0 51	2	+1.12	+0 88	3	+ 7 4	dK5pe	.
G39-27 .	15 94	. . .	. . .	.	+0 65	−0 06	2	+14 9	DC	40
G86-B1A	14 20	+1 00	+1 03	1	+1 66	+1 41:	2	+10 7	. .	. .
G86-B1B .	16 20	.	.		+0 31	−0 64:	3	+12 7	DAe	43
GC7413.	7 76	. .	. .		+0 58	+0 08	2	+ 4 8	(F8)	
G102-39 . . .	15 86	. . . .	. . . .	.	+0 05	−0 76	3	+12 9	DC	44
G105-B2A .	13 25	+1 05	+0 905	2	+1 48	+1 23	3	+ 9 9		.
G105-B2B	16 58	. . . .	. . .	.	+0 21	−0 72	2	+13 2	. . .	47
G87-28	14 60	+1 34	+1 25	1	+1.68	+1 21	4	+12 2	sdM6	. .
G87-29. .	15 64				+0 30	−0 55	5	+13 4	4670	51
G107-69 .	13 52				+1 69	+1 15	3	+13 5:	sdM5	. .
G107-70	14 62	. . .	. . . .	.	+0 99	+0 40	3	+14 6:	DC	52
G111-72	13 18	+1 00	+0 88	2	+1 52	+1 34	2	+ 9 8	sdM2	. .
G111-71.	16 58	. .	. . .	.	+0 36	−0 58	2	+13 2	DA, F	58
LDS235A	11 63	+0 64	+0 39	2	+0 995	+1 00	2	+ 6 8	dK3	.
LDS235B	15 55				−0 06	−0 93	2	+10 7	DB	63
G116-14	9 00		.		+0 68	+0 18	2	+ 5 4	dG5	
G116-16 . .	15 32	.	.		+0 24	−0 53	2	+11 7	DAs	64
G117-B15A	15 52				+0 20	−0 56	3	+13 4:	DA	65
G117-B15B	16 10	. . . .	. . .	.	+1 60	.	3	+14 0:	(dM2)	
G117-B11A .	15.17	+1 28	+1 11	1	+1 60	. . .	2	+11 2	.	.
G117-B11B	17 24	. . .	. . . .	.	+0 40	−0 51	2	+13 3	. .	68
L970-27 .	12 55	+1.29	+1 005	2	+1 52	+1 33	3	+10 8	dM6	.
L970-30	12 92	. . . .	. . . .	.	+0 09	−0 69	3	+11 2	DA	76
G148-6 .	14 09	+1 32	+1 15	3	+1 63	+1 14:	3	+11 5	dM4p	. .
G148-7 . .	13 60	. .	. . .	.	+0 03	−0 67	3	+11 0	DAn	83
L1405-40A	15 55	+1 26	+1 25	2	+1 41	+0 73	3	+12 4	dM2e	.
L1405-40B	15 55	. . .	. . .	.	+0 23	−0 58	4	+12 4	DA	84
G148-B4A .	15 12	+1 25	+1 15	1	+1 58	.	1	+11 5		. .
G148-B4B .	16 95	. . . .	. . . . .	.	+0 38	−0 46	1	+13 3	. . . .	89
G61-16 .	13 48	+0 91	+0 75	3	+1 47	+1 10	2	+ 9 0	sdM2	. .
G61-17 .	15 86		. .		+0 22	−0 53	3	+11 4	DAs	92
W485A	12 30	. . .	. . . . .	.	+0 08	−0 61	3	+11 1	DA	99
W485B. .	14 34	+1 82:	+1 325	2	+1 63	+1 48	3	+13 1	dM5	
LDS455A	13 85	+1 20	+0 94	2	+1 54	+1 20:	4	+10 2	. .	. . .
LDS455B .	15 55				−0 06	−0 83	2	+11.9	(DA)	101
LP135-154	15 74				+1 56	+1 56	3	+11 0:		. . .
LP135-155	16 24				+0 23	−0 60	3	+11 5:	. .	112
+1°3129A	9 78				+0 53	−0 02	2	+ 4 8	dG0	. . .
+1°3129B.	15 27				−0 32	−1 19	2	+10 3	DAwk	113
−37°6571A	6 02	.			+0 72	+0 29	2	+ 5 5	(dG6)	. .
−37°6571B	12 80	. .	. . .	.	+0 30:	−0 40:	2	+12 2	DAs	114
W672A	14 00	+1 43	+1 21	2	+1 54	+1 33	5	+11 9	sdM6	. . .
W672B	14 26	.	. . .	.	+0 13	−0 59	5	+12 2	DA	123
G140-B1A	9 36	+0 46	+0 33	2	+0 95	+0 795	2	+ 6 3	dK2	.
G140-B1B	15 72	. .	. . .	.	+0 10	−0 78	2	+12 7	DC:	124
G142-B2A .	12 68	+1 16	+0 95	2	+1 54	+1 3:	2	+10 2	sdM2	. . .
G142-B2B .	14 00	. . .	. . .	.	+0 12	−0 60	2	+11 5	DAn	130
LDS678A*	12 12	+1 40	+1 09	3	+1 63	+1 42	3	+12 5	dM5	. . .
LDS678B	12 24	. . .	. . . .	.	+0 07	−0 84	4	+12 6	DAwk	131
LDS683A	13 60	+0 98	+0 725	2	+1 49	+1 4:	3	+ 8 8	sdM1	. . .
LDS683B	15 95	. .	. . . .	.	+0 05	−0 76	2	+11 1	DA	132
G24-10	13 20	+1 40	+1 20	2	+1 54	+1 15	3	+11 8	dM5	. . .
G24-9. .	15 67	. .	. .	.	+0 40	−0 44	3	+14 3	DC:	138
LDS749A .	9 89	+0 60	+0 47	3	+0 96	+0 48	5	+ 7 2	sdK4	. . .
LDS749B	14 73	. . .	. . .	.	−0 07	−0 92	3	+12 0	DB	145
L1512-34A	11 68	+1 25	+1 10	1	+1 55	+1 12	6	+11 2	dM5	. . .
L1512-34B .	12 90				+0 15	−0 61	3	+12 4	DA	162

overcome these difficulties, most of the red companions to white dwarfs have been observed in the $(R - I)$ system (Kron, Gascoigne, and White 1957). The observations on this system were all made with the 100-inch reflector and an RCA 7102 multiplier using the original filters, kindly put at our disposal by Dr. Kron. The calibration $(M_V, R - I)$ relation will be discussed in more detail elsewhere but the relation adopted here is shown in Figure 1, where individual points represent stars with trigonometric parallaxes greater than 0.125″ and a total weight greater than 35 (Jenkins 1952, plus later determinations). The $(M_V, B - V)$ relation for the stars in Figure 1 is shown in Figure 2 where the individual objects are indicated by dots. The $(M_V, B - V)$ relation between $B - V = +0.8^m$ and $+1.4^m$ for the extended Hyades group is shown in Figure 2 by a straight line. The red companions in Table 3, for which values of M_V were obtained from the observed values of $(R - I)$, are shown as open circles; one star from Table 3, L1405-80A (No. 84), which is discussed in the notes to Table 1, may be a composite system and is shown as a cross. The values of M_V derived from the values of $(R - I)$

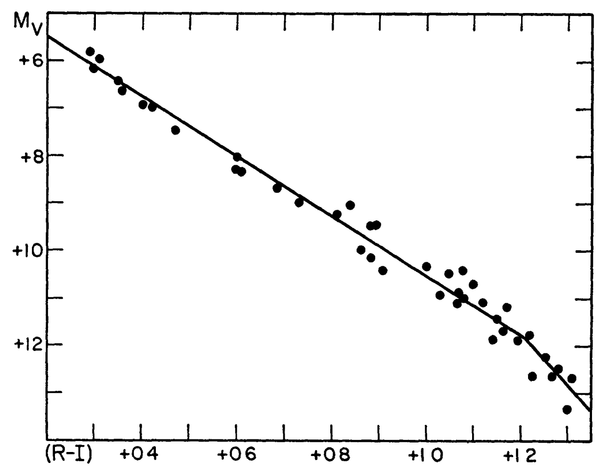

FIG. 1.—The $(M_V, R - I)$ relation for main-sequence stars with trigonometric parallaxes, determined at more than one observatory, greater than 0.125″.

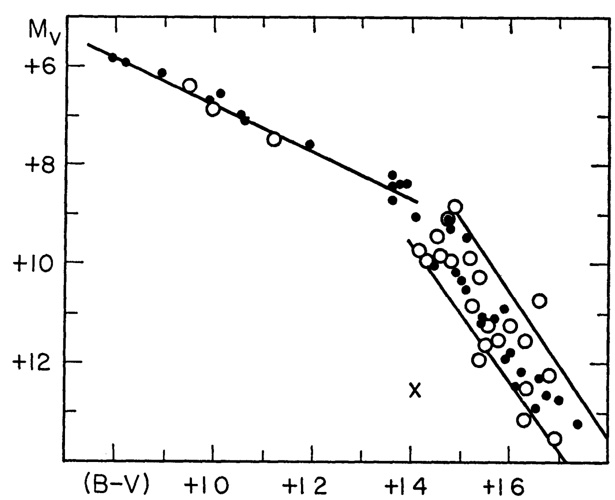

FIG. 2.—The $(M_V, B - V)$ relation for stars in Fig. 1 (*filled circles*) and the red companions to white dwarfs in Table 3 (*open circles*); the luminosities are obtained from Fig. 1 and the $(R - I)$ colors. The position of L1405-40A, from Table 3, which may be composite, is indicated by a cross at the luminosity obtained from the $(R - I)$ color.

and Figure 1 are probably correct to 0.1^m or 0.2^m, whereas luminosities obtained from values of $(B - V)$ greater than $+1.4^m$, and the relation in Figure 2, would have a much larger uncertainty. Table 3 contains very preliminary spectral types of some of the red companions from low-dispersion spectra; they are plotted in Figure 3 as a function of $(R - I)$, and no large systematic differences between "subdwarfs" and normal dM objects can be seen.

The white-dwarf members of some galactic clusters are listed in Table 4; the individual objects are discussed in the notes to Table 1. Moduli of $V_E - M_V = 5.50^m$, 3.00^m, and 5.55^m have been used for the Pleiades, Hyades, and Praesepe clusters, respectively.

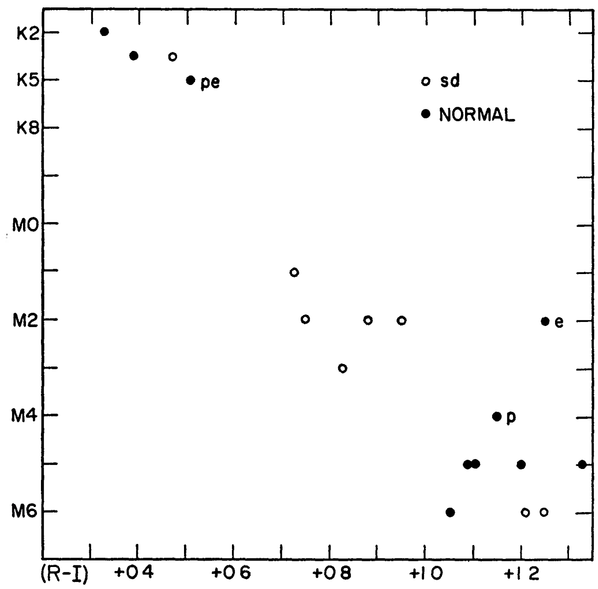

FIG. 3.—The correlation between the spectral types, from low-dispersion spectra, of the red companions to white dwarfs in Table 3 and the $(R - I)$ colors.

TABLE 4

WHITE DWARFS IN GALACTIC CLUSTERS

Name	M_V	$U-V$	Table 1
(Pleiades)			
LB1497	+11 0	−1 30	25
(Hyades)			
HZ4.	+11 5	−0 52	26
LB1240	+12 3	−0 48	28
LB227	+12 4	−0 56	29
HZ10.	+11 1	−0 41	30
HZ2	+10 9	−0 93	31
HG7-138	+12 6	+1 37	32
VR7	+11 3	−0 86	36
VR16	+11 0	−1 06	37
HZ9	+11 0	−0 36	38
HZ7	+11 2	−0 92	39
G39-27	+14 9	+0 59	40
HZ14	+10 8	−1 19	42
(Praesepe)			
LB390.	+12 2	−0 62	59
LB1847	+12 6	−0 45	60
LB393	+12 1	−0 56	61

The (M_V, $U - V$) relation for the white dwarfs in Tables 2, 3, and 4 is shown in Figures 4 and 5; a plot of the (M_U, $U - V$) relation shows little difference from these figures and is not reproduced. The wide base-line, ($U - V$) colors are used to avoid the effects of the lines on the B magnitudes, although they are still sensitive to the Balmer continuum. In Figure 4 the cluster stars are indicated by open circles, crosses, and plus signs for the Pleiades, Hyades, and Praesepe clusters, respectively. The size of the dots, representing the stars for which trigonometric parallaxes are available, is inversely proportional to the uncertainty of the parallax; a few stars with a trigonometric parallax less than 0.1″, based on the results from only one observatory, are represented by dots

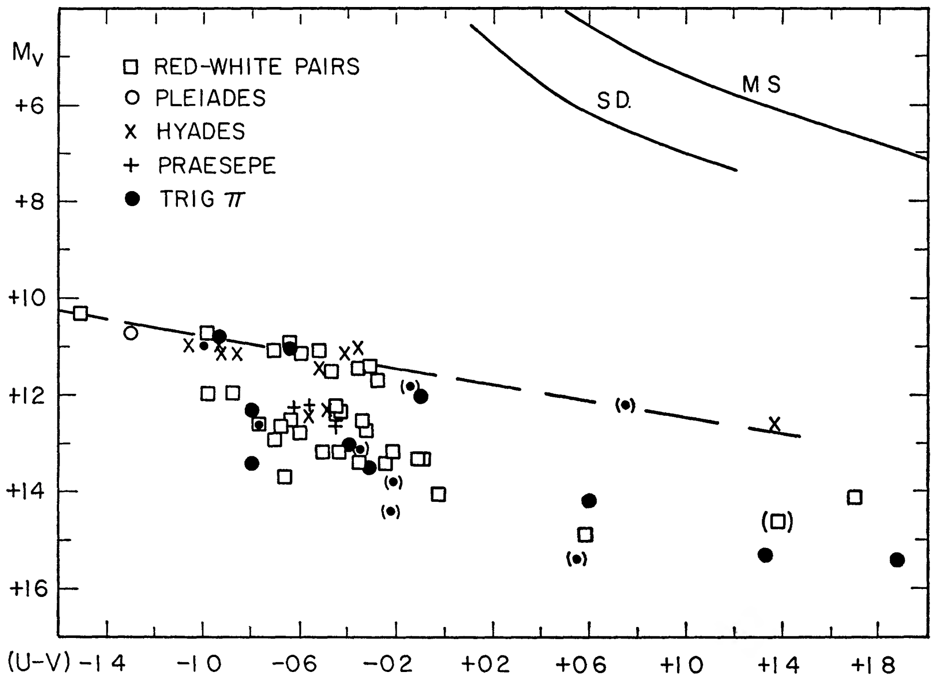

FIG. 4.—The (M_V, $U - V$) diagram for white dwarfs with known trigonometric parallaxes from Table 2 (*filled circles*), (2) red-dwarf companions from Table 3 (*open squares*), and (3) members of galactic clusters from Table 4 (*crosses*, Hyades; *open circle*, Pleiades; and *plus signs*, Praesepe). Part of the normal main sequence and the extreme subdwarf sequence, uncorrected for line-blanketing effects, are also shown.

inclosed in parentheses. The white-dwarf components of wide binaries in Table 3 are indicated by open squares. In Figure 5 we show the spectral peculiarities, described below, as a function of color and luminosity; for white dwarfs the symbol "D" should be understood before all spectral types.

An obvious feature of Figures 4 and 5 is the apparent division of the white dwarfs into two groups consisting of (1) those that cluster, with very little dispersion, about the relation $M_V = +11.65^m + 0.85\ (U - V)$, and (2) those that show a somewhat larger dispersion about a similar but probably steeper relation, with a zero-point approximately 1.5^m fainter. The extension of the first group to colors redder than $(U - V) = -0.1^m$ is dependent upon two stars that require special comment. The object at $M_V = +12.6^m$ and $(U - V) = +1.37^m$ is HG7-138 (No. 32), which is near the center of the Hyades cluster and has the proper motion of a cluster member ($\mu = 0.11''$, $\theta = 99°$). The spectrum shows relatively sharp and weak H- and K-lines of Ca II and a possible broad blend at λ 3590, near the strong lines of Fe I. This feature is stronger in VMa 2 (No. 5), which is considerably bluer and hotter; the Fe I lines are relatively much weaker in HG7-138. The object at $M_V = +13.0^m$ and $U - B = +0.75^m$ is G14-24 =

Ross 974 (No. 96), for which the Cape Observatory parallax is 0.074″ ± 0.011″. The spectrum of this star is sdK, with a radial velocity of +158 km/sec; it has weak, but sharp lines even at 38 Å/mm, which seems hardly compatible with very high surface gravity, and it resembles the subdwarf LPM 661 (No. 10367 in the *Mount Wilson Radial Velocity Catalogue*). G14-24 falls in the region of *UBV* diagram (see Fig. 6) where subdwarfs and white dwarfs are indistinguishable from color alone. If the star is a subdwarf, the photometric parallax, after correcting for line blanketing, is 0.006″ and the space motion is $(UVW) = (-236, -324, -44)$. A re-examination of the Cape parallax series (Stoy 1964) indicates that the parallax is quite reliable. These sharply contradictory results must be left unresolved.

The possible existence of two sequences of white dwarfs was noted by Parenago (1946). Kaplan (1950) suggested that the sequence of brighter white dwarfs requires the presence of thermonuclear energy sources, whereas the fainter stars obtain energy only by cooling

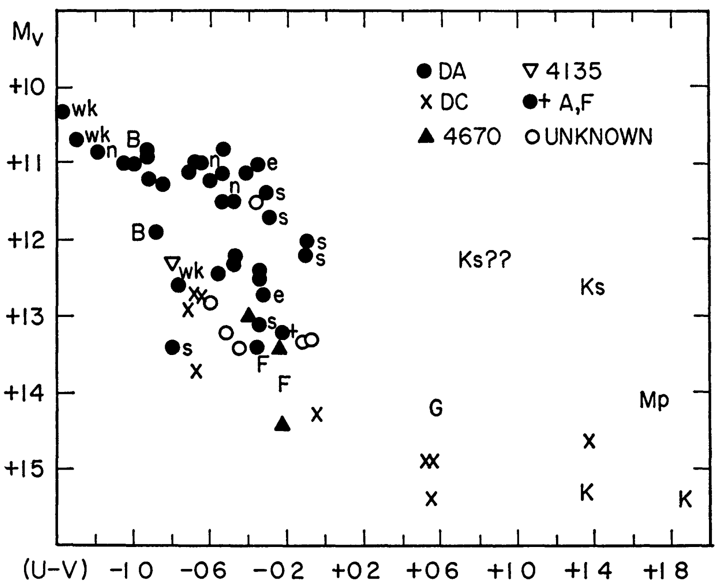

FIG. 5.—Like Fig. 4 except that spectral types are indicated. The doubtful object G14-24 (No. 96) is indicated by "Ks??" and α CMa B (No. 49) by the filled circle at $M_V = +11.1^{\rm m}$, $U - V = -1.1^{\rm m}$.

of the nucleons. The two groups could have a different mean mass, the larger masses corresponding to the smaller radii. There may be a gravitational-energy source in stars with incomplete degeneracy, there may be significant chemical inhomogeneity, but the existence of thermonuclear sources in a completely degenerate star is unlikely since it leads to vibrational instability. Other possibilities include the presence of inhomogeneous compositions, such as a hydrogen envelope and a core of He or heavier elements.

The well-defined nature of the $(M_V, U - B)$ relations for white dwarfs in Figure 4 permits rather accurate estimates of the luminosities of the other stars in Table 1. These estimates are based on the following assumptions: (1) Objects bluer than $(U - V) = -0.9^{\rm m}$ are assumed to fall on the relation $M_V = +11.65 + 0.85\ (U - V)$, and the luminosity is listed on line 1 of Column IX in Table 1. (2) Objects with $(U - V)$ between $-0.9^{\rm m}$ and $0.0^{\rm m}$ are assigned two luminosities; one is based on the relation given in assumption (1) and is listed on line 1 of Column IX; the other is based on the assumption that the star falls in the middle of the scatter for the fainter group of white dwarfs and is listed in line 2 of Column IX. (3) Objects redder than $(U - V) = 0.0^{\rm m}$ are assumed to be similar to the fainter white dwarfs, $M_V > +14^{\rm m}$, in Figure 4, and the luminosity is listed in line 2 of Column IX. The space motions resulting from luminosities listed in lines 1 and 2 of Column IX are given in Columns V and VI, respectively. The well-marked separation between the two groups of white dwarfs in Figure 4 is reflected in the nature of the spectral lines, in that those following the relation $M_V = +11.65^m + 0.85\ (U - V)$ have appreciably sharper absorption lines than the fainter stars.

III. COLORS AND LINE BLANKETING

The distribution of the white dwarfs in the $(U - B, B - V)$-plane is shown in Figure 6, where the standard relation for Pleiades-Hyades stars (Eggen 1963*b;* Sandage and Eggen 1959) is shown as a continuous curve. The region of this plane occupied by the extreme subdwarfs is also indicated in Figure 6; the subdwarfs with $B - V$ between $+0.4^m$ and $+0.9^m$ cannot be distinguished from white dwarfs on the basis of color alone. The bluest white dwarfs, types DO, DB, and hot DAwk stars, are also easily confused with the hottest main-sequence stars and with the subluminous O- and early B-type stars. The black-body relation in Figure 6, with the temperatures labeled, is that given by Matthews and Sandage (1963). The white dwarfs with continuous spectra and those of λ 4670, DF, and DG type have weak lines and colors that fall near the black-body relation. The displacement of the DA stars from this relation is caused by a combination of line blanketing (affecting the observed values of B and U) and Balmer continuum (affecting the observed values of U). In Figure 7, for the DO, DC, and DA stars, we show the ultraviolet deficiency, $(U - B)_{\text{def}}$, which is the deviation at a given $B - V$ from the black-body relation in Figure 6, as a function of the equivalent width of Hγ. It is noteworthy that the DC stars are apparently not entirely free of absorption or of gray-body deviations from a Planck distribution since some have relatively large values of $(U - B)_{\text{def}}$. There is a real possibility, however, that the extrapolation of the black-body relation to values of $B - V > +0.5^m$ is not as linear as is shown in Figure 6.

The values of $(U - B)_{\text{def}}$ in Figure 7 are only $\pm 0.1^m$ for small values of W(Hγ) and clearly increase to near $+0.25^m$ for large values of W. However, a detailed interpretation of $(U - B)_{\text{def}}$ is extremely complex (e.g., Weidemann 1963). The visual classification of the spectra leads to a distinction as to line sharpness, with sharp lines called DAs, diffuse lines DAn, and shallow, weak lines DAwk; Figure 7 shows that there is at least a statistical meaning to these subjective impressions. The DAs stars are largely the cooler group and have large values of $(U - B)_{\text{def}}$ for their $B - V$ colors whereas the DAwk stars have $(U - B)_{\text{def}} \sim 0$.

The run of the equivalent widths, W(Hγ), and the widths at half-intensity, $w_{0.5}$(Hγ), are shown in Figure 8. The maximum effect of the hydrogen lines occurs at a higher temperature than for main-sequence objects, and the lines are very much stronger and wider. Weidemann (1963) lists W(Hγ) as a function of T_e for a surface gravity of $\log g = 8$ and finds a maximum at $T_e = 11700°$ K. Our curve, plotted against $(U - V)$ is more asymmetric because of the rapid decrease in the Balmer discontinuity which compresses the $(U - V)$ scale below $T_e = 10000°$ K.

Greenstein and Oke (unpublished) find W(Hγ) = 22 Å for α CMa B (No. 49) which leads, from Figure 8, to the values of $B - V = -0.12^m$ and $U - B = -1.03^m$ given in Table 1.

IV. SPECTRAL TYPES

Except for a few southern stars and older spectra published elsewhere, the spectral types in Table 1 are based on Palomar observations. The general system has been described by Greenstein (1958, 1960); the λ 4670 stars are now known to show the $C_2(1,0)$ and (0,0) bands, and the unique λ 4135 star has the still unidentified Minkowski bands. Stars classified as DC have no lines or bands detectable by visual inspection of the plates. The objects brighter than 15^m have usually been studied spectrophotometrically on two or more plates of 180 Å/mm, whereas the fainter stars have usually been observed only once; for a few stars fainter than 16.5^m, spectra of 390 Å/mm were used. Equivalent widths based on one plate, especially of 390 Å/mm, have only small weight. The faint

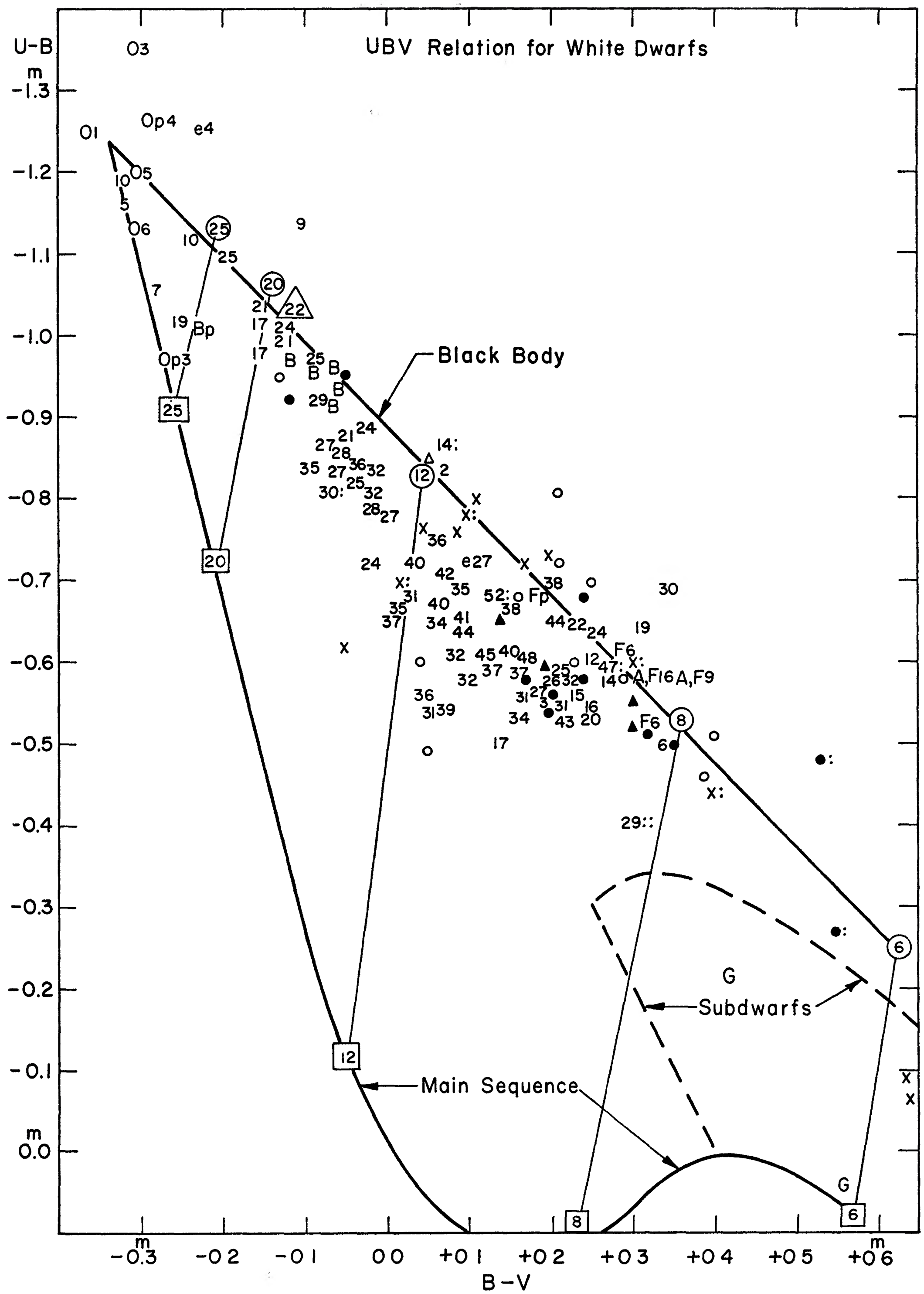

FIG. 6.—The $(U - B, B - V)$ diagram for the stars in Table 1, which are indicated as follows: (1) the numbers represent the values of $W(H\gamma)$ in DA stars; (2) for DO, the type, O, and the value of $W(H\gamma)$ are given; (3) crosses represent continuous spectra; (4) filled triangles represent λ 4670 stars; (5) open circles represent stars for which spectra are not available; and (6) filled circles represent DA stars for which measures of W are not available; emission stars are indicated by "*e*." The squares on the main sequence and the circles on the black-body relation give the effective temperatures in units of 1000° K. The large triangle near the black-body line represents the position derived for α CMa B from the value of $W(H\gamma) = 22$ Å.

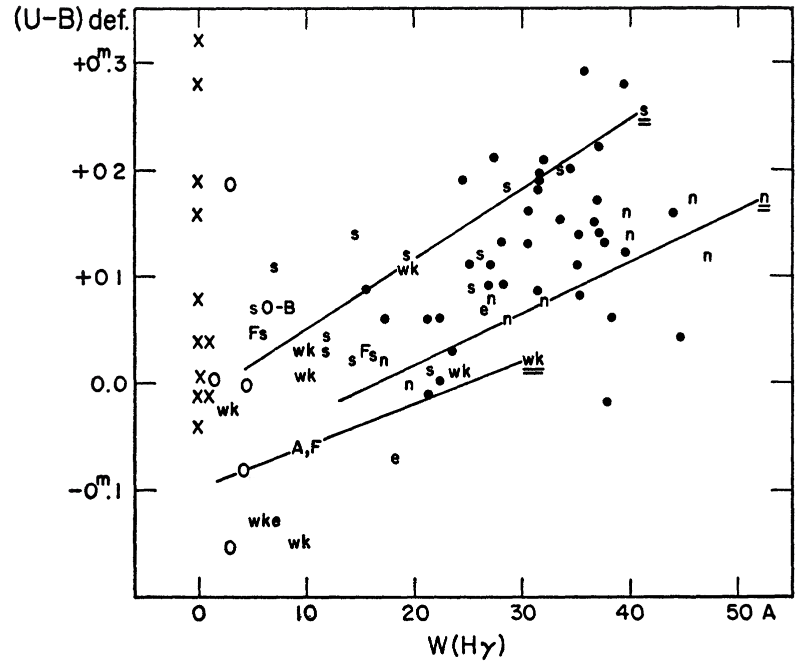

FIG. 7.—The relation between $(U - B)_{def}$ and $W(H\gamma)$, where $(U - B)_{def}$ is the displacement of the stars in Fig. 6 from a black body of the same $(B - V)$.

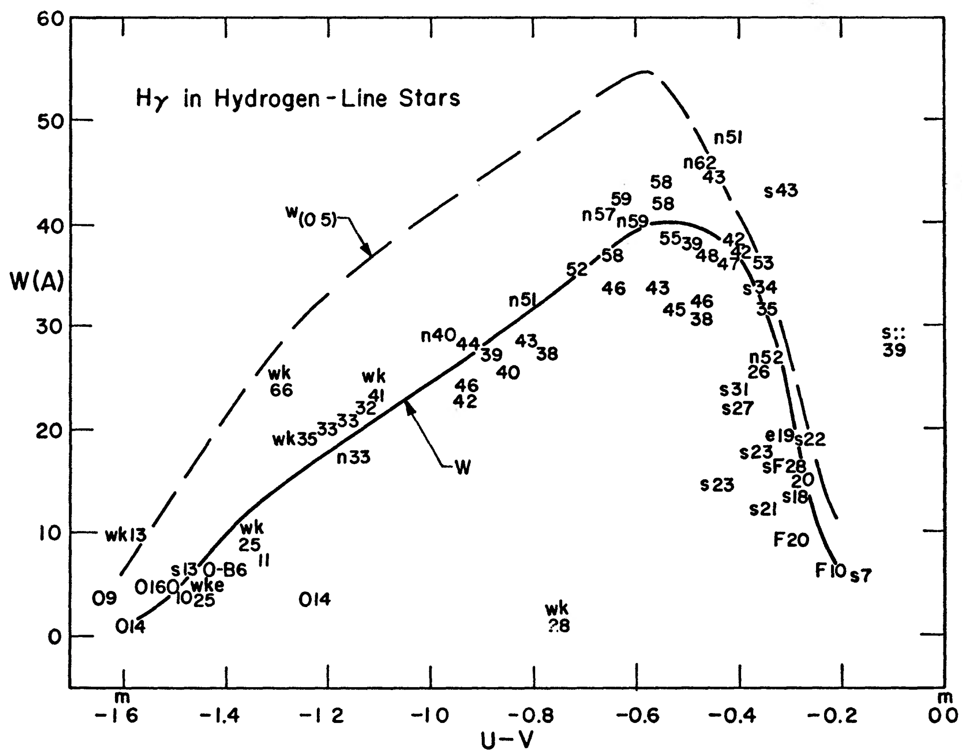

FIG. 8.—The correlation between $W(H\gamma)$ and $(U - V)$ for DO and DA stars. The run of $w_{0.5}(H\gamma)$ for these objects is also shown as a broken curve; the actual values of $w_{0.5}$ are given at the $(W, U - V)$ position of each star.

stars of type DC are especially difficult to establish and are often indicated in Table 1 by a colon. Several emission-line objects are indicated, but except for Feige 24 (No. 20) they are in low galactic latitudes and the emission lines come from H II regions on which they are superposed; when Balmer lines and λ 3727 of [O II] are visible, this explanation is clearly correct. However, HZ9 (No. 38) and F24 have no λ 3727 and also show the K-line in emission. These objects are suspected of being unresolved visual binaries with a very faint dMe companion. Finally, the most difficult stars to classify are the DO-B systems. They are almost indistinguishable from very hot sdO stars. It is possible that some of them are not white dwarfs, and there are a few cases in which the decision can only be made when trigonometric parallaxes are available.

Among the DA stars, some with weak lines, called DAwk, deviate greatly from the mean relations between color and W or $w_{0.5}$ with the lines being either too wide or too narrow. The stars classified as diffuse, called DAn, are apparently more typical DA stars. A most striking feature is the concentration of DAs stars in the color range of $U - V$ from -0.45^{m} to -0.15^{m}; only one hotter object is called DAs. In spite of the sharpness of the line cores, no more Balmer lines are visible in the DAs stars than in the average DA object; normally, H8 is the last line seen, although H9 is occasionally visible.

Figure 6 shows that some regions of the $(U - B, B - V)$-plane are occupied by special types of white dwarfs. The DA stars range over an enormous variety of colors. Their deviations from the black-body relation, which reach a maximum near $B - V = 0.0^{m}$, are closely correlated with the equivalent width of Hγ. The DB stars are very highly concentrated in the range of $B - V$ from -0.23^{m} to -0.06^{m}, all having nearly the same value of $U - B$. Objects that are both bluer and redder than the range of colors covered by the DB stars are of type DA; the DB types appear only when there is an extremely high He/H ratio. Stars with continuous spectra are found mainly when $B - V > 0.0^{m}$ and include such red objects as G107-70 (No. 52) with $B - V = +0.99^{m}$. The stars with Ca II lines appear very abruptly at $B - V = +0.3^{m}$. There are only a few stars of type DA, F, which show both hydrogen lines and a weak K-line, and among the later types there is no clear correlation of type with color. The so-called DM stars, which are all very faint and have only been observed at 390 Å/mm in the blue, have diffuse Ca I as well as Ca II and barely detectable TiO. It is hoped that spectra in the red can be obtained for some of these objects. The spectra are so peculiar that they probably cannot be confused with those of ordinary dM stars, but not enough is known about the spectra of either low-mass, partially degenerate stars or extremely metal-deficient dM stars to eliminate these stars as possible explanations of the observed spectra.

V. TEMPERATURE AND RADIUS

Given its mass and chemical composition, the radius of a star is fixed and its age determines its luminosity if no nuclear or gravitational energy sources are present. The evolutionary tracks in a luminosity-temperature plane are approximately straight lines with a time scale that increases greatly as the star cools and fades. Eventually the empirical $(M_V, U - V)$ diagram of Figure 4 can be converted into others involving L, T_e, R, and age, but the observed quantities are remote from those needed for this transformation. A theoretical $(M_V, U - B)$ diagram for a given radius and temperature can be computed for black bodies because the response-curves for the (UBV) photometry and the bolometric corrections for black bodies are known with some precision, but for real stars with non-gray atmospheres and with absorption lines and continua, many additional steps are required. We have made the following preliminary approach to the problem.

1. Using the black-body computations of Matthews and Sandage (1963) and the temperature scale and bolometric corrections for main-sequence stars given by Harris (1963), we have connected black-body and main-sequence stars of the same temperature in Figure 6. This procedure provides a first-order estimate of the temperature scale for white dwarfs, omitting the complexities of line and continua effects. The Balmer discon-

tinuity is smaller, by a factor larger than 2, at log $g = 8$ than at log $g = 4$, and the resulting widening of the lines affects the spectral region passed by the B filter more than that passed by the U filter; the effect of the lines on $(U - B)$ is small whereas that on $(B - V)$ reaches 0.2^m. The continuous absorption affects the $(U - B)$ by nearly 0.5 mag. at the maximum of the Balmer continuum near 11000° K. The deviations from the black-body relation of the individual stars should be correlated with the strength of Hγ, as is shown in Figures 6 and 7. The detailed corrections to (UBV) required by these line and continua effects have been computed by Weidemann (1963, Figs. 14, 16, 17, and 20). We have obtained temperatures from the colors by projecting the stars from their observed position in Figure 6 back to the black-body relation on a track parallel to the lines connecting the main-sequence stars and black bodies of the same temperature. Although this method is subject to systematic errors which will be at a maximum near 12000° K, where the hydrogen lines are strongest and the line-blanketing effects are greatest, the resulting temperatures agree systematically with Weidemann's values over the range from 15000° to 6000° K (Fig. 9).

2. Three $(M_V, U - V)$ relations for black bodies of radii $0.1\odot$ and $0.03\odot$ are shown in Figure 10; the dashed relations are based on the (UBV) calibration by Matthews and Sandage (1963) and the continuous relation, for $R = 0.01\odot$, is based on a slightly different calibration by Oke (1963) and Mihalas (1963). The shaded areas in the figure represent the position of the two main groups of white dwarfs, plotted without corrections to the observed colors.

The large body of fainter white dwarfs have, on the average, the correct slope for constant radius of $0.01\odot$, and a mass, which depends on the composition, near $0.7\odot$. The scatter within this group is real, so that the stars represent a wide range of masses, some of them approaching the Chandrasekhar limit. It is apparent that, in the color range of $(U - V)$ from about -1.0^m to 0.0^m, corrections of 0.2^m to 0.4^m are required in $(U - V)$. The redder objects may have ultraviolet absorption lines and should also be shifted to the left in Figure 10. Individual red, degenerate stars are so far above the R $0.03\odot$ line in Figure 10 that an ultraviolet depression of nearly a magnitude, caused by metallic absorption, is needed to move them into a more normal position.

The slope of the well-defined group of brighter white dwarfs is distorted in Figure 10 by the presence of hydrogen lines which cause only small effects at $(U - V) = -1.0^m$ and at 0.0^m, but relatively large effects in between. Correcting for this distortion would cause these objects to fall more nearly along a sequence of constant radius and mass in Figure 10, $R \sim 0.02\odot$ and $m \sim 0.3\odot$. The star, 40 Eri B (No. 33), for which the observed mass is $0.45\odot$ (van den Bos 1926), falls in this group.

The other objects for which an accurate determination of the mass is available are α CMa B (No. 49) and α CMi B (No. 53). Unfortunately, colors are unobtainable at present for α CMi B because of its proximity to Procyon. The W(Hγ) for α CMa B leads, from comparisons with normal stars, to $(B - V) = -0.12^m$, $(U - B) = -1.03^m$ colors which, with $M_V = +11.1$, place this object among the brighter white dwarfs. From Figure 6 we derive a temperature near 18000° compared to 17000° obtained by Oke (1963) from the line profile and a rough model atmosphere. Either temperature gives a radius near $0.01\odot$ and the mass, for a pure helium interior, is about $0.75\odot$ from the Chandrasekhar models and somewhat less, depending on composition, from the Hamada and Salpeter (1961) zero-temperature, hydrogen-poor models. The well-determined mass, from the orbital system, is $1.05\odot$ (van den Bos 1960). It should be noted that α CMa B may be a double star. Fox (1925) and van den Bos (1929) independently saw it as a double in 1925 and 1927 when the apparent separation changed from 1″ to 2″ and the position angle changed by 100°. This companion, which was 2 or 3 mag. fainter than α CMa B, has not been seen since.

Little can be said about the ages of the white dwarfs on the basis of their cooling at a constant radius. The cooling times are dependent upon the opacity of the non-degenerate envelope and on the chemical composition. For the same composition, the cooling

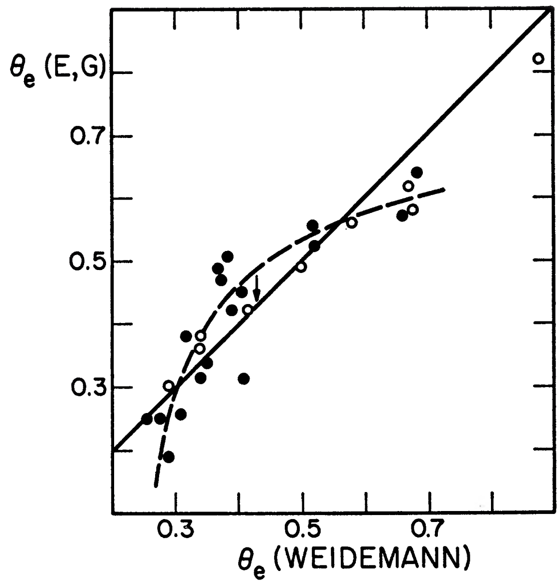

FIG. 9.—The effective temperature derived statistically from Fig. 6, $\theta(E, G)$, correlated with Weidemann's values from Hγ line profiles (*filled circles*) and (*UBV*) photometry (*open circles*). The positions of three stars analyzed by spectral scans (Oke 1963) are indicated at the tips of arrows. Our values of the effective temperature have a systematic deviation from those of Weidemann, as is shown by the dashed curve, caused by partial neglect of line-blanketing effects, but over a wide range of temperatures the two scales are in fair agreement.

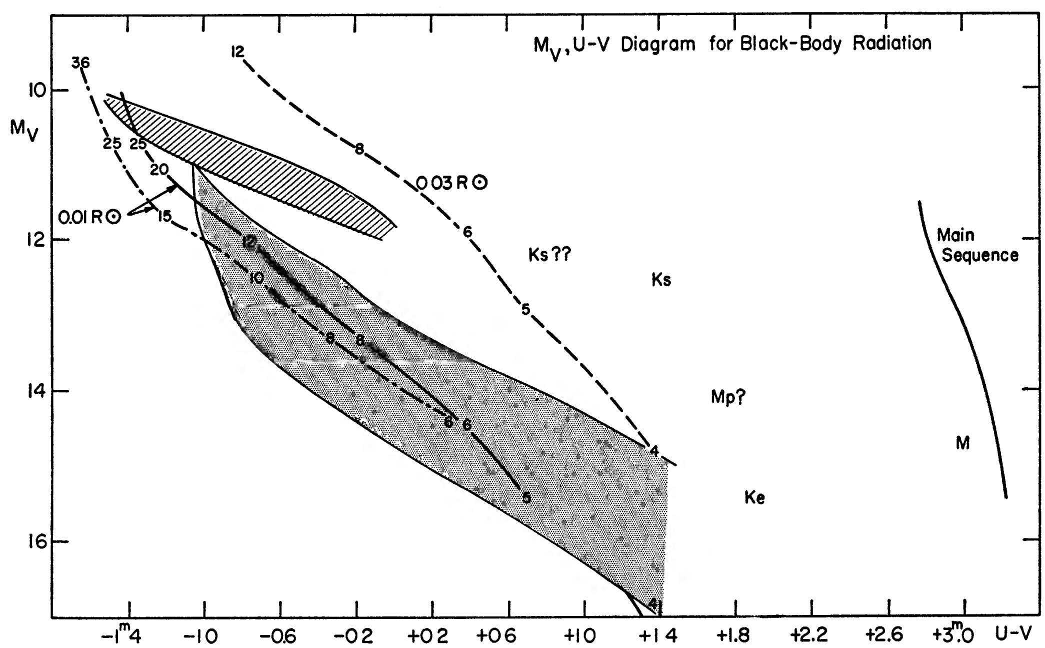

FIG. 10.—(M_V, $U - V$) diagram for black bodies with 0.01 and 0.03 solar radii. The continuous relation for 0.01 solar radius represents a (*UBV*) calibration of black bodies by Mihalas (1963), whereas the dashed relations represent the calibration by Matthews and Sandage (1963). The shaded regions represent the main body of white dwarfs in Fig. 4; a few red objects are indicated by their spectral types.

time scale goes roughly as $M/L^{5/7}$, so that near the end of the brighter sequence of white dwarfs, $U - V = 0.0^m$, the cooling time scale is ten times shorter than on the fainter sequence; because of the higher luminosity, the probability of discovery of the brighter objects is higher by approximately the same ratio. If HG7-138 (No. 32), with $(U - V) = +1.37^m$ and $M_V = +12.6^m$ in Figure 10, is a member of the Hyades cluster and reasonable corrections of about 0.4^m are applicable to $(U - V)$, it has a radius near 0.03⊙, a mass less than 0.1⊙, and a cooling time near 2×10^8 years or less; its cluster age is probably near 5×10^8 years. On the other hand, the DC star G39-27 (No. 42), with $M_V = +14.9^m$ at $(U - V) = +0.59^m$, is almost certainly a Hyade and the cooling time is more nearly 5×10^9 years. The probable white dwarf members of the Hyades and Praesepe clusters are shown in Figure 11. The dozen members of the Hyades cluster constitute about one-half the number predicted from the "initial" and present luminosity functions of the cluster (Sandage 1957). Hoyle, Fowler, Burbidge, and Burbidge (1964) have labeled as "superstitition" the conventional view that mass ejection reduces the mass of some stars to the Chandrasekhar limit for white dwarfs, and dismiss the supporting evidence for this view, the presence of white dwarfs, with the claim that these white dwarfs have evolved from stars whose masses have never appreciably exceeded this limit. In view of the fact that extreme evolution in the Hyades cluster has only involved stars with masses greater than 2⊙, and in view of the fair agreement between the observed and predicted number of white dwarfs, it appears that, in this cluster at least, the conventional belief in the substantial ejection of mass is not a superstition.

VI. SPACE MOTIONS

There are only a dozen stars in Table 1 for which the total space motion is almost certainly more than 100 km/sec. This is, of course, a lower limit to the number of such objects because of the uncertainty in the luminosity of stars with $(U - V)$ between -0.9 and 0.0 and the lack of radial velocities for most of the objects. Half of these high-velocity stars may be members of a moving group. Bell (1962) and Bell and Rodgers (1964) pointed out that the proper-motion vectors of the three known λ 4670 stars, W219 (No. 24), L789-14 (No. 41) and L145-141 (No. 82), and two stars with continuous spectra, L97-12 (No. 56) and L1363-3 (No. 148), show a convergence to the point $A = 14^h44^m$, $D = -59°$. The trigonometric parallaxes of W219 and L145-141 give values of $V = 4.74\ \mu/\pi \sin \lambda = 150$ km/sec for the total space motion of the group; λ is the angular distance of the stars from the point (A, D). The possible members of this group are listed in Table 5 where the radial velocities, ρ, have been computed from the relation $\rho = V \cos \lambda$ and are given in parentheses. The parallaxes, π, in parentheses, have been computed from the relation for V given above. In addition to the apparent parallelism of the proper-motion vectors, the only checks on the group hypothesis would be radial velocity determinations, which may be impractical, or parallax observations of the five stars for which the parallaxes are not already available; a preliminary parallax of $0.17'' \pm 0.04''$ was determined for L97-12 at the Harvard Boyden station. The star G7-17 (No. 27) requires special comment. Although separated from W219 by about 0.5°, the large proper motion and its position angle indicate that the stars may be moving together. The spectrum (see notes to Table 1) could be that of either a late-type degenerate star or a very weak-lined M-type dwarf with hydride bands, similar to G95-59. The position in the $(M_V, U - V)$-plane of the stars used to construct Figure 1, plus a few late-type companions to main-sequence, *F*-, and *G*-type stars (Eggen 1963*b*), are shown as open circles in Figure 12. The break in the main sequence near $(U - V) = +2.6^m$, caused by the TiO bands, is evident in the figure. The system of ADS 2757 contains a pair of extremely weak-lined K-type dwarfs which show an ultraviolet excess that indicates a metal abundance near 0.05 that of the Sun. This system also contains the M-type dwarf G95-59 (Eggen 1963*a*) with $M_V = +11.8^m$ and $(U - V) = +4.10^m$, placing it in Figure 12 on the extension of the main sequence. The spectra of this star

TABLE 5

Possible Members of the W219 Group

Table 1	Name	α (1950)	δ (1950)	M_V	$U-V$	Sp.	μ	θ	π	ρ	U	V	W
24.	W219	3^h41^m6	+18°18′	+14.4	−0.22	λ4670	1″25	162°	0.068(8)	(−110)	−100	−100	+20
27	G7-17	3 58.7	+18 36	+14.7	+2.97	DKp	1.24	165	(068)	(−110)	−108	− 88	+12
41.	L879-14	4 35.4	− 8 53	+12.7	−0.51	λ4670	1.49	171	(052)	(− 48)	−112	− 90	− 8
56.	L97-12	7 52.8	−67 38	+14.5	. . .	DC	2.05	135	(100)	(−119)	−119	− 87	− 2
82.	L145-141	11 42.9	−64 34	+13.0	−0.41	λ4670	2.68	97	.203(23)	(+140)	−117	−100	+ 1
148.	L1363-3	21 40.3	+20 45	+10.8	−0.52	DC	0.70	202	(033)	(− 63)	−107	− 96	−14
156.	G28-27	22 54.9	+07 40	+12.4	−1.0:	λ4670	0.31	220	(0.0105)	(− 58)	−130	− 96	−60

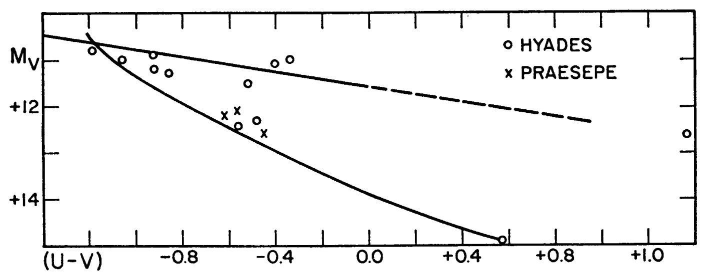

Fig. 11

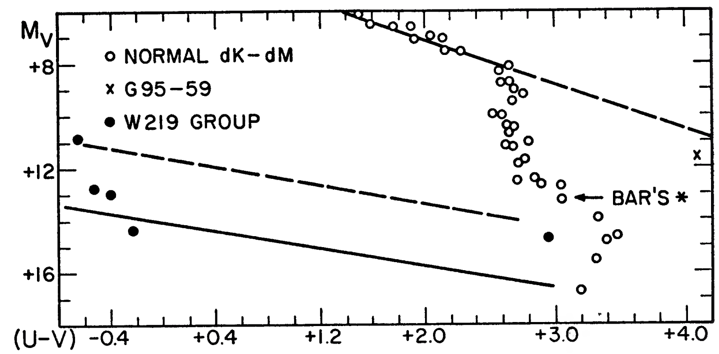

Fig. 12

Fig. 11.—The white-dwarf members of the Hyades and Praesepe clusters with the run of the mean relations for the two groups of stars in Fig. 4 indicated by continuous curves.

Fig. 12.—The position of some members of the W219 group in the (M_V, $U-V$) diagram compared to main-sequence, K- and M-type stars and the extreme subdwarf of M type, G95-59. Although the spectrum of G7-17 ($M_V = +13.4^m$, $U - V = +2.97^m$) in the group is similar to that of G95-59, it is almost certainly a degenerate star.

contain no TiO bands. Although the spectra of G7-17 are similar to those of G95-59, the position of the former in Figure 12, near the intersection of the normal M-type dwarf sequence with that of the degenerate stars, indicates that it, like the other objects in the W219 group, may be degenerate. Barnard's star, which is undoubtedly a weak-lined object but which *does* show TiO bands in the spectrum, is also indicated in Figure 12. Another peculiar object in Table 5 is the new λ 4670 star G28-27 (No. 156). Three observations of the color show considerable scatter; the star may be variable. Spectra at 390 Å/mm show H- and K- lines and give some indications of compositeness. Additional spectroscopic and photometric observations will be obtained.

In addition to the fourteen members of the Hyades and Praesepe clusters, there are nine low-velocity field stars in Table 1 that may belong to the Hyades group. These stars are listed in Table 6 where the values of (UVW) are followed, in parentheses, by the percentage of the radial velocity that contributes to these vectors. The penultimate column of the table contains the values of the radial velocity that would make the values of (UVW) similar to those of the Hyades cluster and that were used in computing

TABLE 6

WHITE DWARFS IN THE HYADES GROUP

Name	M_V	$U-V$	W(Hγ)	U (Per Cent ρ)	V (Per Cent ρ)	W (Per Cent ρ)	ρ	Table 1
				Hyades Cluster				
HZ4..	+11 5	−0 52	38 4	+41	−20	− 2	+36 0	26
LB1240	+12 3	−0 48	32 1	+35	−17	−16	+36 0	28
LB227	+12 4	−0 56	41 2	+40	−17	− 2	+36 7	29
HZ10	+11 1	−0 41	37 4	+35	−16	−15	+37.0	30
HZ2 ...	+10 9	−0 93	22 7	+32	−18	−20	+37 3	31
HG7-138 .	+12 6	+1 37	3 8	+38	−15	− 7	+37 5	32
VR7 .	+11 3	−0 86	(32)	+40	−15	− 3	+38 1	36
VR16	+11 0	−1 04	(25)	+40	−14	− 2	+38 5	37
HZ9	+11 0	−0 36	30 2	+40	−17	− 3	+38 8	38
HZ7	+11 2	−0 92	23.7	+40	−13	− 3	+39 0	39
G39-27	+14 9	+0 59	DC	+38	−16	0	+36 0	40
HZ14	+10 8	−1 19	20 7	+40	−13	0	+40 2	42
				Praesepe Cluster				
LB390..	+12 2	−0 52	.	+36	−17	0	+33	59
LB1847. . .	+12 6	−0 44	. ..	+33	−19	+ 4	+33	60
LB393 ..	+12 1	−0 56	...	+37	−19	− 2	+33	61
				Field Stars				
LDS275	+13 0:	.. ..	DC	+42(+8)	−17(+98)	−10(+19)	+20	66
L825-14	+10 6	−1 17	17 1	+34(+16)	−16(−76)	−28(+63)	0	70
L970-30	+11 2	−0 60	35 1	+39(+10)	−16(−65)	−20(+76)	0	76
R627 ...	+13 8	−0 21	5.6	+46(+25)	−19(−25)	−18(+94)	0±	79
L1261-24	+13 1	−0 30	DC:	+41(+11)	−17(−24)	− 9(+96)	0±	85
HZ28 .	+10 9	−0 86	25 3	+45(+19)	−18(+18)	+13(+97)	+20±	90
L19-2 .	+11 0:	. .	(28)	+40(−57)	−15(−76)	− 3(−33)	0	110
W1346 .	+10 8	−0 94	27 0	+42(−38)	−18(+91)	0(−16)	0	139
G67-23	+12 7	−0 50	38 1	+46(−1)	−17(+85)	−18(−53)	− 6	155

the listed space motions. In a few stars situated near the galactic poles, these assumed values are followed by "±" to indicate that the values of (UV) are almost independent of the radial velocity. One star in the table, W1346 (No. 139), has been observed for radial velocity at the Mount Wilson (+103 km/sec) and McDonald (+24 km/sec) observatories, but the results are extremely uncertain. The values of the luminosities given in Table 6 are taken from lines 1 or 2 of Column IX in Table 1. The system of G39-27/28 (No. 40), which may be an outlying member of the cluster, requires special comment. It lies in the direction of the cluster center, and although the proper motion is 2.5 times larger than the cluster mean, the direction of the motion is the same as that for the bright cluster stars. The radial velocity is +36 km/sec from two coudé plates, compared with +37 km/sec computed on the assumption of cluster membership. A

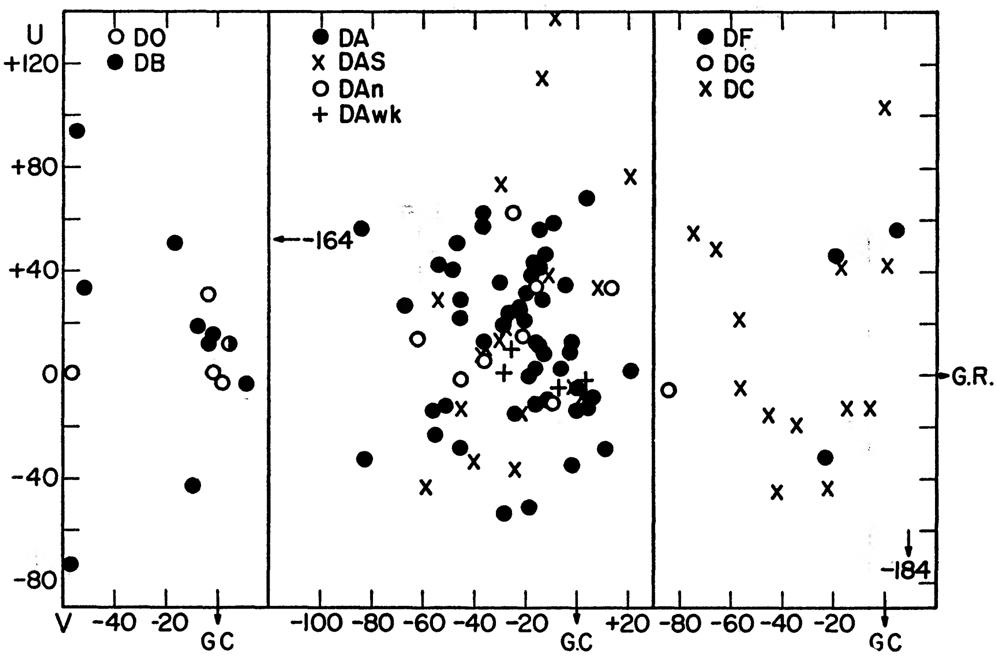

FIG. 13.—The distribution of (UV) values for the DO, and DB stars, the DA stars, and the DF, DG, and DC stars in Table 1. When two luminosities are given in Table 1, the lower value has been used in computing the values of (UV) in the figure.

value of $M_V = +7.4^m$ is derived for the A component from the available observations of both $(B - V)$ and $(R - I)$ given in Table 3. The value of $(U - B)$ is somewhat bluer than expected for the observed $B - V$ (Sandage and Eggen 1959), but is not unprecedented among cluster members redder than $B - V = +1.1^m$ (Johnson, Mitchell, and Iriarte 1962, Fig. 6). The luminosity of cluster members with $B - V = +1.1^m$ is near $M_V = +7.5^m$, and since this value is nearly 8 mag. fainter than the brightest main-sequence stars in the cluster, some objects of this color may only now be completing the pre–main-sequence contraction phase of their evolution. Strong hydrogen emission appears in the spectra of G39-28. Hydrogen emission is known in only one other K-type Hyades star, No. 288 (Johnson, Mitchell, and Iriarte 1962) for which $M_V = +8^m$, $B - V = +1.22^m$, and $U - B = +1.01^m$ (Wilson 1964). The distance of 16 pc for the system of G39-27/28 is somewhat closer than the usual limits of 30–50 pc found for the Hyades cluster.

Pavlovskaya (1956) has analyzed the space motions of a group of suspected white dwarfs, largely southern stars from Luyten's lists for which photoelectric color indices are not available. Her list of 132 stars contains 32 stars from Table 1; the luminosities based on proper motions do not differ systematically from ours. The mean deviation, on the assumption that the fainter of our sequences contains most of the stars, is $\pm 0.9^m$.

Iwanowska and Opaska-Burnicka (1962) used the proper motions of white dwarfs of known parallax or $B - V$ color and studied the separation of the stars into high and low tangential velocity groups. They have also attempted to use the proximity of the apices of the motions of individual stars to the apex of the high- and the low-velocity main-sequence stars as a population discriminant for the white dwarfs. Their Population II group contains a large percentage of stars with peculiar spectra that populate our lower sequence.

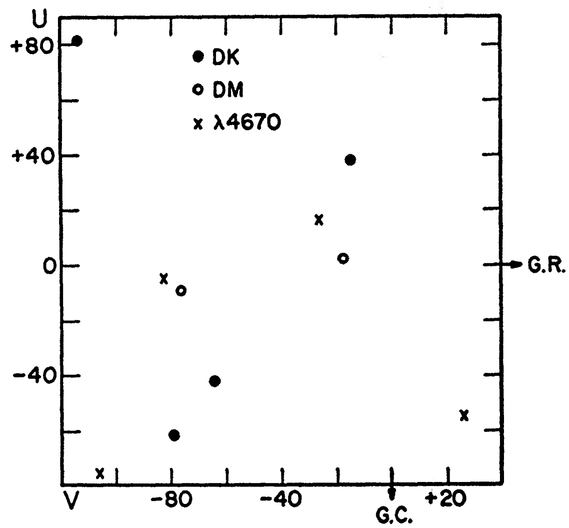

FIG. 14.—Like Fig. 13 for the DK, DM, and λ 4670 stars

The distributions of the (UV) vectors for DO and DB, DA, DF, and DG, and DK, DM, and λ 4670 stars in Table 1 are shown in Figures 13 and 14. In the majority of cases these vectors do not involve the radial velocity. When two luminosities are listed in Table 1, the space motions from the lower value are used. Although, as would be expected, the velocity dispersion increases from the DO and DB stars to those of DK, DM, and λ 4670 types, there are low, and also relatively high, velocities in all four spectral groups considered here. The disk populations of all ages are apparently still producing white dwarfs.

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