

PHOTOMETRY OF F-K TYPE BRIGHT GIANTS AND SUPERGIANTS. III. THE LUMINOSITY, REDDENING, AND HEAVY ELEMENT ABUNDANCE OF GK STARS

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Received 1993 December 7; revised 1994 January 31

ABSTRACT

The reddening, luminosity, and heavy element abundance of 250 bright giants and supergiants of type GK are discussed on the basis of 4 color, DDO, RI, and Geneva photometry. Bright giants of type GK with age greater than 5×10^8 yr, and of type G0/3 with age greater than 2×10^8 yr, are very scarce in the solar neighborhood. The median space motion vectors of the bright giants and supergiants with well determined space motions are $(U, V, W) = (+10.6, -13.2, -7.7) \pm (12.3, 8.8, 8.8)$ km/s. The M_1 index for 4 color photometry, when corrected for luminosity (gravity) effects, is sensitive to heavy element abundance in the F type stars but not in those of GK type. The CN index reflects the heavy element abundance of the GK stars but may not be reliable for those of type G0/3. The available spectroscopic determinations of $[\text{Fe}/\text{H}]$ give mixed results with the two largest samples [McWilliam, ApJS, 74, 1075 (1990); Brown *et al.*, ApJS, 71, 293 (1989)] being internally consistent but with a large zero-point difference. There is a similar zero-point shift in the peak frequency of the photometrically determined values of $P[\text{Fe}/\text{H}]$ for the F type and for the GK type stars. There is little evidence for an appreciable galactic, radial gradient in the $P[\text{Fe}/\text{H}]$ values. A previously noted correlation of the heavy element abundance index, ΔM_1 , with the amplitude defect in the B light curves of Cepheids, F_B , and interpretation of the (PLF_B) relation as a $(PL[\text{Fe}/\text{H}])$ relation needs further investigation in light of the apparent sensitivity of M_1 to Fe/H for the F stars (the domain of the Cepheids with $P < 10$ d) and lack of this sensitivity for the G0/3 star (domain of the Cepheids with $P > 10$ d).

1. INTRODUCTION

The normal (class III) giants of types G and K in the young disk population are extensively discussed in Eggen (1993) on the basis of the following calibrations: reddening;

$$(b-y)_0 = 0.826(R-I) + 0.722M_1 - 0.550(b-y) + 0.353, \quad (1)$$

luminosity;

$$M_V = 4.86(C_1) - 5.86(R-I)_0 + 0.95, \quad (2)$$

where $C_1 = C_1 - 0.220(b-y)$,

$$M_V = 6.60 - 13.00(R-I)_0 - 20.00\Delta(45-48)_0 - 3.12(C_m)_0, \quad (3)$$

where

$$\Delta(45-48)_0 = (45-48)_0 - 0.600(42-45)_0 - 0.605, \quad (4)$$

$$(C_m)_0 = (41-42)_0 - 1.66[(45-58)_0 - 0.45(42-45)_0 - 0.792], \quad (5)$$

heavy element abundance;

$$P[\text{Fe}/\text{H}](\text{DDO}) = 3.12\Delta\text{CN} + 0.031, \quad (6)$$

$$P[\text{Fe}/\text{H}](M_1) = 3.2\Delta(M_1)_0 + 0.100, \quad (7)$$

where

$$\Delta\text{CN} = (C_m)_0 - 1.112(R-I)_0 + 0.131, \quad (8)$$

$$\Delta(M_1)_0 = (M_1)_0 - 2.15(R-I)_0 + 0.240. \quad (9)$$

The $(b-y)$, M_1 , C_1 and (R,I) systems are defined in Eggen (1982) and the DDO system in McClure (1976).

As noted in Eggen (1993) the bright giants (BG) and supergiants (SG) require a different calibration of the photometric parameters in terms of luminosity and reddening. The adopted relations are:

$$E(b-y) = 1.085(R-I) - 0.603[(42-45) - \delta(45-48)] + 0.151, \quad (10)$$

where

$$\delta(45-48) = (45-48) - 0.600(42-45) - 0.695, \quad (11)$$

$$M_V(\text{DDO}) = 3.43 - 14.00(R-I)_0 - 20.0\delta(45-48)_0 \text{ for } (R-I)_0 \leq 0.375,$$

$$M_V(\text{DDO}) = 1.75 - 9.50(R-I)_0 - 20.0\delta(45-48)_0 \text{ for } (R-I)_0 \geq 0.375, \quad (12)$$

$$M_V(4C) = 2.75 - 10.50(R-I)_0 - 7.6\delta[u-b], \quad (13)$$

¹Operated by the Association of Universities for Research in Astronomy, Inc. under cooperative agreement with the National Science Foundation.

TABLE 1. ($R-I$) photometry.

HD	R	R-I	Δ	N	HD	R	R-I	Δ	N	HD	R	R-I	Δ	N
3488	5 ^m 97	0 ^m 352	2	2	65699	4 ^m 62	0 ^m 345	0	2	97534	4 ^m 00	0 ^m 347		1
6446	6.55	0.528	4	2	66604	9.08	0.362	0	2	98386	6.77	0.457	0	2
7927	4.67	0.385		1	66678	8.88	0.322	2	2	98782	7.74	0.359	4	2
8267	7.64	0.345	7	3	67243A	5.67	0.359	5	3	99154	7.90	0.334	3	2
12409	8.43	0.309	0	2	67243C	10.46	0.770	15	2	99313	7.91	0.395	2	2
13640	8.30	0.424	5	4	67323	2.66	0.079		1	99576	8.46	0.462	1	2
14985	8.25	0.453	4	5	67594	3.94	0.314	5	2	100137	7.46	0.380	1	2
15589	8.48	0.384	0	2	68111	7.66	0.405	7	2	100278	7.35	0.288	1	4
16901	5.05	0.310		1	70046	8.44	0.414	2	3	101314	6.70	0.374	5	2
17005	6.40	0.260	4	2	70302	5.79	0.355	0	2	101570	4.46	0.400	2	3
18145	6.03	0.348	4	2	70385	7.22	0.404	2	2	102305	8.42	0.371	0	2
20902	--	0.214		1	70555	4.20	0.460	1	2	102839	4.33	0.475	2	3
20176	5.77	0.350	4	3	71181	7.06	0.403	2	2	103134	9.07	0.356	1	2
23010	6.39	0.088	5	2	72125	7.72	0.459	2	2	103225A	7.26	0.457	4	2
24107	7.02	0.380	1	2	72561	5.52	0.353	4	2	104096	8.71	0.469	4	2
25049	6.73	0.391	4	2	73155	4.42	0.455	0	2	104215	7.13	0.485	2	2
26630	--	0.383		1	74180	3.32	0.359		1	105138	5.72	0.409	6	2
27385	6.64	0.596	2	4	75276	5.48	0.275	5	2	105340	4.53	0.466	5	2
28085	6.83	0.474	3	3	75586	7.74	0.374	4	2	106057	5.15	0.300	2	2
28794	5.36	0.455	2	2	76006	6.97	0.290	4	2	106981	7.05	0.440	4	2
31767	3.87	0.480	4	2	77020	5.39	0.353	4	2	107285	7.19	0.441	5	2
31910	--	0.310		1	77615	5.23	0.445	5	3	108282	7.55	0.369		1
38871	4.88	0.305	7	4	77996	4.94	0.427	3	4	110483	8.09	0.344	1	2
39400	4.18	0.481	3	2	78791	4.25	0.302	3	2	111315	5.05	0.369	5	2
40805	3.52	0.375	1	2	79698	5.20	0.289	6	3	111790	5.78	0.356	1	2
41701	6.16	0.281	5	3	79737	6.80	0.533	7	2	112762	7.62	0.493	2	2
42456	6.94	0.470	2	3	79739	8.36	0.446	4	2	113778	5.12	0.336		1
43497	7.20	0.528	2	2	80108	4.25	0.616	2	2	114533	5.41	0.358	2	4
44812	6.51	0.340	5	2	80128	6.74	0.391	4	2	114756	6.81	0.508	2	2
45416	4.74	0.380	0	2	81502	5.58	0.495	3	2	117341	7.99	0.341	0	2
45829	5.94	0.489	6	2	81949	6.42	0.350	2	2	117740	3.38	0.391		1
47209	6.59	0.306	0	2	82122	8.93	0.346	7	2	118520	5.56	0.393	2	2
47475	5.84	0.360	4	3	82150	3.90	0.500	4	3	119605	5.24	0.285	4	2
47667	4.16	0.535	5	3	82205	4.88	0.462	5	2	120112	7.00	0.458	2	3
48616	6.36	0.359	5	2	82415	8.07	0.289	2	2	120537	8.19	0.438	0	2
49050	7.16	0.525	5	2	83111	6.50	0.383	3	2	121281	8.67	0.512	5	2
49068	6.86	0.440	5	2	83609	7.66	0.288	2	2	121678	7.43	0.384	0	2
49091	6.13	0.555	5	2	83657	7.35	0.398	0	2	122223	4.18	0.204		1
49102	7.16	0.391	1	2	83898	8.32	0.418	4	2	123349	7.94	0.447	0	2
49105	7.34	0.405	4	3	84341	8.05	0.487	7	2	124198	8.05	0.362	0	2
49212	7.30	0.400	4	3	84441	2.70	0.275	5	2	124602	7.62	0.499	2	2
49367	6.76	0.391	3	2	84533	8.06	0.530	2	2	125809	5.90	0.404	3	2
49778	6.64	0.353	6	2	84610	7.42	0.303	0	2	126152	7.27	0.661	5	2
50372	6.65	0.355	0	2	85205	7.96	0.328	1	2	127885	8.61	0.485	1	2
51043	6.00	0.345	2	2	85530	7.48	0.376	2	2	128713	5.75	0.396	3	2
52497	4.88	0.312	2	3	85656	4.93	0.441	5	2	129330	6.79	0.398	2	2
53003	6.64	0.281	3	2	86453	6.84	0.263	1	2	131296	5.12	0.438	1	2
54605	1.70	0.195		1	87109	7.14	0.412	1	2	131425	5.45	0.356	0	2
55751	4.85	0.400	7	2	87323	7.00	0.350	6	2	132223	7.51	0.391	2	2
56695	8.98	0.343	6	2	87951	8.36	0.333	1	2	132242	6.22	0.211		1
57118	5.89	0.277	2	2	88056	7.99	0.302	0	2	132594	7.59	0.366	1	2
57623	3.70	0.253		1	88069	7.86	0.300	4	4	134270	4.98	0.306:		1
58134	7.15	0.359	4	2	88092	7.30	0.283	3	3	134704	7.50	0.324	0	2
58367	4.59	0.335		1	88495	8.08	0.307	4	2	135551	7.70	0.362	1	2
58526	5.60	0.310	0	2	88756	7.26	0.449	2	2	135913	7.80	0.326	5	2
59367	8.13	0.382	4	2	89175	7.47	0.343	2	2	136474	7.36	0.409	2	2
54669	5.76	0.375	1	3	89716	7.36	0.343	2	2	136505	6.14	0.376	1	2
59890	4.90	0.300	5	2	89373	7.46	0.456	5	2	136537	6.27	0.409	4	2
61561	8.92	0.347	2	2	89805	5.54	0.547	5	2	136635	10.33	0.219	5	2
61714	7.43	0.328	4	2	89874	7.30	0.291	0	2	136636	8.19	0.374	1	2
62236	7.52	0.369	4	2	89925	6.90	0.298	2	2	137465	5.62	0.338	3	2
63609	7.86	0.346	5	2	90301	7.86	0.274	0	2	141120	7.06	0.416	0	2
63700	2.37	0.370	5	2	90772	4.46	0.247		1	141767	4.61	0.391		1
63822	5.59	0.413	2	3	91629	7.12	0.259	0	2	142277	7.15	0.390	4	2
18. 2032	9.48	0.357	1	2	92449	3.87	0.322	4	2	142584	6.68	0.442	3	2
64320	6.13	0.434	5	2	93807	6.54	0.416	2	2	142811	8.52	0.464	2	2
64571	6.27	0.263	0	2	94584	8.05	0.445	1	2	142822	6.70	0.487	2	2
64572	4.95	0.356	5	2	95393	6.64	0.482	2	2	143084	5.75	0.556	4	2
64858	8.11	0.344	8	2	96544	5.48	0.426	6	3	143119	6.77	0.500	3	2
65228	3.95	0.236		1	96746	8.39	0.318	0	2	144338	6.30	0.512	2	2
65297	7.24	0.447	0	2	97189	7.78	0.422	2	2	145302	9.10	0.386	2	1

TABLE 1. (continued)

HD	R	R-I	Δ	N	HD	R	R-I	Δ	N	HD	R	R-I	Δ	N
145336	8 ^m .66	0 ^m .400	6	2	161614	5 ^m .41	0 ^m .600	0	1	184624	9 ^m .24	0 ^m .446	2	2
-53.7416	9.83	0.535	4	3	162585	6.11	0.499	2	2	185018	6.60	0.298	2	3
145544	3.33	0.370	1	1	163413	6.67	0.335	3	2	185758	4.13	0.246		1
146143	4.60	0.310		1	165462	5.93	0.397	4	2	185958	4.00	0.342		1
146148	6.96	0.413	2	2	165833	7.22	0.491	2	2	186962	7.20	0.342	5	2
146525	7.81	0.377	5	2	166263	7.15	0.516	0	2	187203	6.06	0.330	3	2
147225	5.36	0.438	1	3	168245	7.14	0.403	2	2	187299	6.35	0.565		1
147266	5.70	0.300	7	2	168356	6.99	0.353	0	2	187308	7.02	0.346	1	2
148218	5.41	0.494	4	2	169660	6.68	0.443	0	2	187401A	7.47	0.370	5	2
149900	7.88	0.541	4	2	170053	6.64	0.486	7	2	189337	6.00	0.325	1	3
150085	6.28	0.259	1	1	170457	6.26	0.532	2	2	190113	7.05	0.565		1
150090	5.99	0.456	2	2	170886	6.26	0.568	3	2	192713	4.72	0.334		1
150416	4.44	0.403	1	2	172365	6.00	0.299	4	2	192876	3.76	0.365		1
150479	7.50	0.564	2	2	172508	6.64	0.726	4	2	193370	4.90	0.272		1
150675	6.58	0.415	5	3	173388	6.51	0.754	4	2	193721	5.21	0.465	2	2
151834	7.22	0.728	3	2	173568	7.64	0.546	2	2	194093	2.00	0.222	5	2
151856	7.30	0.999	9	3	173764	3.69	0.391		1	198590	6.53	0.282	3	2
153573	7.64	0.474	0	2	174349	6.49	0.584	2	2	199997	7.36	0.274	0	2
153639	6.40	0.452	5	2	174947	5.15	0.429	4	2	201409	6.88	0.301	0	2
LS14	9.60	0.382	5	2	176123	5.99	0.357	2	2	202109	2.82	0.218	6	2
154853	6.19	0.450	3	2	177433	6.96	0.390	0	2	204867	2.59	0.270	2	2
155072	9.06	0.432	3	2	178853	8.58	0.432	6	2	205935	5.92	0.374	4	2
LSS3970	8.55	0.988	7	4	178937	5.19	0.350		1	207089	4.65	0.473	3	3
156866	5.41	0.358	1	2	179440	7.78	0.536	5	2	209750	2.56	0.310	3	2
157549	7.64	0.558	2	2	179590	7.34	0.305	1	2	211300	5.70	0.370	5	2
157819	5.47	0.355	2	2	180262	5.90	0.350	5	2	216206	5.66	0.400		1
159181	2.36	0.332		1	180540	4.46	0.321	2	2	217476	4.27	0.620	5	3
159633	5.71	0.420	5	2	182635	4.38	0.262		1	219135	7.20	0.405		1
160529	5.82	0.650	9	3	183418	7.38	0.346	9	2	222574	4.50	0.279		1
160706	7.38	0.654	0	2	183791	7.52	0.412	0	2	222820	4.94	0.545		1
161388	7.34	0.686	0	2	-0.3783	8.68	0.394	0	2	223047	4.50	0.375	7	2
161471	2.82	0.218		1	184591	6.94	0.312	1	2					

where $\delta[u-b] = [u-b] - 3.80(R-I)_0 - 0.240$. The temperature range discussed here is limited to $(R-I) = 0.275$ to 0.425 mag.

The previous two papers of this series contain the intermediate band and $H\beta$ observations (Eggen 1992, hereafter referred to as Paper I) and the luminosities, reddenings, and heavy element abundances of the F type stars (Eggen 1991, hereafter referred to as Paper II). In addition to Paper I, the intermediate band observations are in Eggen (1989ab). A collection of my (R,I) results is in Table I, where most of the photometry is based on observations with the 0.6, 1.0, and 1.5 m reflectors on Cerro Tololo. Observations on the DDO system, made with the Cerro Tololo reflectors and not already in the literature, are listed in Table 2, where Δ is the mean deviation of a single observation from the mean values of 45–48, 42–45, and 41–42, respectively. A few errors in Table 1 of Paper I are corrected in Table 3.

BG and SG members of four galactic clusters and three wide binary systems are listed in Table 4. The values of M_V from DDO and 4 color (4C) photometry, respectively, are derived with Eqs. (12) and (13). The reddening is from Eq. (10). The individual clusters and binary systems are discussed in the following.

NGC 2287: The three giants give a mean modulus very similar to the 9.35 ± 0.20 mag derived from 25 B and A type members (Eggen 1981). All three stars are radial velocity (Sowell 1987) and proper motion (Ianna *et al.* 1987) members of the cluster. The cluster members are represented by closed circles in the $[u-b]$, M_V plane of Fig. 1 with the symbol for peculiar A type stars accompanied by “p”. The

continuous curves represent isochrones for 3×10^8 and 4×10^8 yr (Bertelli *et al.* 1992) with $Z=0.02$ and convective overshoot at the stellar cores.

HGC 2516: The cluster contains four red giants but only one, HR 3076 (HD 64320) is in the temperature range considered here. This star gives a reddening and a modulus that agrees well with those found from 35 B and A type cluster members, 8.32 ± 0.22 mag (Eggen & Iben 1991). The cluster members are represented in Fig. 1 with clear circles and “p” accompanies the symbol for those known to be Ap or Bp(si) stars. The objects discussed here are all radial velocity (e.g., Gieseking & Karimie 1982) or proper motion (King 1978) members of the cluster. The brightest cluster star, HR 3147(V 374 Car) is of spectral type Be IVpne and the value of $[u-b]$ is probably affected by the peculiarity. Nevertheless, the star is apparently much younger than the other cluster stars, which are very similar to those in HGC 2287.

NGC 3114: Table 5 contains the results for B type cluster members for which Strömgren photometry was obtained by Schmidt (1982). A half dozen objects, which appear to have a modulus near 10.5 mag, are omitted. The mean modulus and reddening (Eggen 1977) agree well with those obtained for the three red giants in Table 4. Cluster membership is uncertain although Amieux & Burnage (1981) have published radial velocities. Three known Bp(si) stars (Frye *et al.* 1970) in the cluster are added at the end of the table and all of the cluster stars are represented by crosses in Fig. 1 where “p” accompanies the symbol for Bp stars. In Paper II it was found that HD 87283(F2 II), which lies within the cluster boundaries, has a modulus of 10.5 mag, which places it at

TABLE 2. Previously unpublished DDO photometry.

HD	M ₄₈	45-48	42-45	41-42	Δ	N	HD	M ₄₈	45-48	42-45	41-42	Δ	N
6446	7 ^m 81	1 ^m 358	1 ^m 023	0 ^m 149	6.2.6	3	88092	7 ^m 92	1 ^m 132	0 ^m 632	0 ^m 117	6.4.3	5
12409	90.8	1.150	0.769	0.130	0.1.5	2	88495	8.80	1.152	0.883	0.207	1.1.1	2
13640	9.37	1.330	1.055	0.375	3.3.1	2	88756	8.39	1.351	0.993	0.373	3.2.0	2
15589	9.36	1.249	0.996	0.237	1.3.3	2	89175	8.09	1.250	0.956	0.291	0.1.2	2
17005	7.08	1.114	0.676	0.089	6.2.0	2	89373	8.58	1.350	1.064	0.366	1.1.3	2
18145	6.90	1.200	0.887	0.212	5.1.1	2	89805	6.98	1.449	1.176	0.377	1.0.1	2
24107	7.95	1.227	0.953	0.290	0.1.1	2	89874	7.94	1.138	0.649	0.111	1.0.5	2
25749	7.73	1.245	1.004	0.315	1.4.0	2	89925	7.59	1.144	0.665	0.122	2.2.4	2
35949	7.32	0.955	0.439	0.067		1	90301	8.42	1.112	0.611	0.119	3.1.0	2
41701	7.26	1.168	0.824	0.273	1.1.1	2	91629	7.70	1.105	0.607	0.104	2.4.0	2
42456	8.30:	1.199:	0.961:	0.277:		1	93807	7.61	1.353	0.991	0.375	1.1.2	2
43497	8.54	1.407	1.115	0.390	6.3.3	2	94584	9.16	1.278	0.827	0.206	0.0.2	2
44812	7.35	1.237	0.842	0.262	3.0.0	2	95393	7.88	1.374	0.941	0.308	1.1.2	2
45829	7.28	1.481	1.078	0.440	3.1.1	2	96746	9.12	1.163	0.701	0.134	1.1.0	2
47209	7.40	1.186	0.852	0.269	3.4.5	2	97169	8.79	1.268	0.857	0.249	0.0.1	2
49091	7.49	1.404	1.246	0.326	3.3.0	2	98782	8.65	1.204	0.831	0.220	2.1.2	2
49102	8.74	1.234	0.764	0.168	0.3.1	2	99154	8.68	1.166	0.745	0.168	0.0.1	2
49334	8.25	1.270	1.023	0.220	2.2.4	3	94313	8.86	1.236	0.792	0.198	4.4.1	2
49367	7.65	1.267	0.992	0.333	3.2.4	2	100137	8.38	1.232	0.872	0.280	3.7.4	2
49778	7.25	1.208	0.829	0.205	0.3.0	2	101314	7.58	1.215	0.766	0.170	1.1.2	2
50372	7.49	1.261	0.891	0.336	2.2.1	2	103225	8.39	1.292	0.864	0.284	1.0.2	2
51956	7.82	1.124	0.595	0.120	3.4.0	2	104096	9.82	1.263	0.900	0.310	5.1.5	3
52220	7.10	0.126	0.637	0.118	1.0.2	2	104215	8.34	1.390	0.978	0.367	2.3.1	2
55612	8.50	1.003	0.460	0.074		1	104857	8.50	1.300	0.916	0.307	0.2.5	2
56186	8.11	1.084	0.616	0.103	5.1.3	2	105138	6.75	1.298	0.871	0.255	4.3.3	2
56695	9.72	1.178	0.719	0.182	2.0.1	2	106981	8.14	1.298	0.855	0.250	1.0.2	2
58134	8.04	1.242	0.829	0.264	1.0.2	2	107285	8.24	1.250	0.777	0.159	1.2.4	2
59367	8.99	1.206	0.825	0.235	0.1.3	2	108282	8.30	1.145	0.626	0.099	2.4.7	2
61561	9.70	1.180	0.835	0.229	1.0.4	2	110483	8.90	1.250	0.927	0.364	1.4.3	2
61713A	8.13	1.153	0.783	0.148	1.2.3	2	111315	5.98	1.251	0.880	0.359	7.7.1	2
62236	8.48	1.274	0.887	0.320	0.0.3	2	111790	6.68	1.244	0.859	0.269	4.0.2	2
63170	8.68	1.104	0.554	0.108	3.1.0	2	112782	8.81	1.334	0.915	0.357	3.3.0	2
63609	8.62	1.134	0.688	0.127	2.2.2	2	113190	8.41	1.298	0.875	0.240	1.0.1	2
-18.2032	9.44	1.078	0.537	0.113		1	114533	6.24	1.220	0.753	0.164	6.7.7	2
64571	6.96	1.128	0.630	0.118	2.3.1	3	114756	7.85	1.364	0.941	0.337	5.5.3	2
64558	8.92	1.211	0.791	0.196	1.0.3	2	117000	7.23	1.217	0.550	0.067		1
65297	8.30	1.298	0.899	0.295	0.0.0	2	117341	8.81	1.209	0.893	0.319	1.4.1	2
66678	9.60	1.184	0.863	0.220	0.0.1	2	118520	6.50	1.255	0.838	0.234	5.5.6	2
67243A	6.57	1.254	0.827	0.225	0.2.1	2	120432	8.56	1.198	0.715	0.142		1
68111	8.62	1.263	0.839	0.212	3.2.2	2	120537	9.27	1.306	0.893	0.267	6.4.7	2
69444	7.28	1.072	0.503	0.087	4.3.2	3	121938	8.38	1.232	0.773	0.172	4.3.2	2
70046	9.32	1.155	0.711	0.104	2.0.3	2	124198	8.02	1.196	0.849	0.264	7.4.2	2
70385	8.22	1.286	0.878	0.269	2.3.3	2	125809	6.89	1.333	0.916	0.332		1
71181	8.06	1.260	0.869	0.254	2.1.3	2	128713	6.77	1.241	0.891	0.294	0.2.0	2
72125	8.82	1.258	0.909	0.296	2.4.1	2	132594	8.44	1.156	0.723	0.079		1
75586	8.66	1.222	0.917	0.236	1.1.3	2	134704	8.26	1.168	0.762	0.156	3.7.4	2
76006	7.63	1.059	0.539	0.083	3.4.1	3	135551	8.58	1.263	0.906	0.392	6.3.0	2
76340	9.31	1.132	0.653	0.105		1	136456	10.22	1.219	0.836	0.239		1
79737	8.05	1.334	0.845	0.180	1.0.3	2	136474	8.36	1.278	0.849	0.284	0.4.6	2
79739	9.47	1.258	0.811	0.182	2.1.1	2	136505	7.14	1.275	0.874	0.262	1.0.6	2
80128	7.76	1.331	0.935	0.329	2.2.2	3	136537	7.24	1.284	0.868	0.244	5.1.1	2
81949	7.26	1.229	0.806	0.237	6.4.2	4	136636	9.07	1.264	0.916	0.323		1
82155	9.68	1.159	0.761	0.162	2.2.1	2	137465	6.52	1.236	0.811	0.228	3.2.2	2
82415	8.73	1.119	0.611	0.104	2.4.3	3	139915	6.93	1.214	0.741	0.151	1.1.4	2
83111	7.44	1.235	0.900	0.302	1.0.0	2	141120	8.06	1.247	0.783	0.171		1
83609	8.31	1.130	0.681	0.120	3.2.2	2	142277	8.06	1.178	0.777	0.227	6.5.3	2
83657	8.31	1.263	0.902	0.288	0.1.0	2	142584	7.76	1.295	0.893	0.276		1
83898	9.38	1.283	0.878	0.298	3.5.2	2	142644	9.46	1.337	0.905	0.275	0.0.3	4
84341	9.22	1.325	0.986	0.358	1.1.3	2	142811	9.16	1.278	0.895	0.282	0.2.5	2
84533	9.37	1.401	0.989	0.348	2.0.1	2	142822	7.90	1.243	0.767	0.215	1.0.1	2
84610	8.18	1.200	0.862	0.316	1.2.1	2	143084	7.14	1.418	0.997	0.376	2.5.0	2
85205	8.76	1.196	0.827	0.276	1.0.0	2	143119	7.98	1.284	0.833	0.193	1.1.1	2
85530	8.36	1.236	0.839	0.263	0.1.4	2	144338	7.95	1.373	1.041	0.389	5.3.5	2
86453	7.48	1.104	0.656	0.102	2.4.3	3	145302	9.88	1.201	0.833	0.205		1
87109	8.12	1.312	0.930	0.352	2.4.6	2	145336	9.63	1.222	0.880	0.264	4.2.2	2
87323	7.88	1.224	0.786	0.172	1.3.1	2	146148	7.97	1.276	0.868	0.264	3.7.7	2
87951	9.12	1.150	0.719	0.139	4.0.0	2	146525	8.72	1.244	0.819	0.280		1
88056	8.67	1.172	0.691	0.135	1.1.2	2	147225	6.40	1.257	0.816	0.215		1
88069	8.54	1.151	0.666	0.122	6.6.5	2	148218	6.68	1.417	1.048	0.334		1

TABLE 2. (continued)

HD	M ₄₈	45-48	42-45	41-42	Δ	N	HD	M ₄₈	45-48	42-45	41-42	Δ	N
148586	8 ^m 38	1 ^m 093	0 ^m 605	0 ^m 100		1	167506	7 ^m 14	1 ^m 253	0 ^m 903	0 ^m 221	3.2.1	2
150675	7.56	1.259	0.898	0.292		1	168245	8.02	1.210	0.885	0.171	0.3.0	2
151824	9.00	1.553	1.076	0.364		1	168356	7.80	1.190	0.700	0.150	1.1.5	2
151856	8.36	1.302	1.013	0.514		1	169660	7.80	1.352	0.932	0.306	0.6.0	2
152501	8.36	1.268	0.797	0.198		1	170053	7.88	1.344	1.091	0.334	1.3.2	2
153515	8.51	1.261	0.782	0.151		1	170457	7.60	1.387	0.967	0.363	8.6.2	2
153573	8.72	1.267	0.706	0.179		1	170886	7.56	1.380	0.908	0.229	3.3.2	2
153639	7.54	1.344	0.953	0.363		1	172365	6.79	1.100	0.604	0.098	7.6.2	2
153892	8.10	1.253	0.983	0.282		1	172508	8.41	1.551	1.192	0.410	4.5.2	2
LSS3970	11.06	1.546	0.840	0.124		1	173388	8.38	1.562	1.069	0.362	1	1
154813	7.28	1.322	0.951	0.304	1.2.0	2	173568	9.00	1.427	1.008	0.349		1
156768	6.28	1.217	0.827	0.268	2.0.2	2	174349	8.30	1.391	1.251	0.297	2.0.3	2
157549	9.00	1.411	0.979	0.373		1	177483	7.82	1.202	0.885	0.174	2.4.4	2
157919	6.36	1.231	0.860	0.286	4.1.2	2	178937	7.00	1.201	0.693	0.128	1.4.0	2
158476	6.36	1.124	0.638	0.114		1	183418	8.10	1.164	0.809	0.082		1
159633	6.76	1.314	0.889	0.284		1	183791	8.55	1.234	0.757	0.183		1
160706	9.13	1.535	1.104	0.438		1	184591	7.66	1.107	0.731	0.182		1
161388	9.04	1.439	0.930	0.231		1	184624	10.28	1.233	0.957	0.177	7.7.3	2
162585	7.36	1.382	1.005	0.307	2.0.3	2	187203	6.98	1.031	0.678	0.142		1
163020	8.86	1.454	1.119	0.386	4.3.2	2	187308	7.86	1.202	0.900	0.179	4.2.2	2
163413	7.44	1.196	0.742	0.172	2.0.0	2	189337	6.94	1.235	0.839	0.236		1
164774	7.81	1.426	1.023	0.399	0.0.1	2	198590	7.24	1.162	0.821	0.280	2.6.1	2
165462	6.80	1.194	0.761	0.138	3.3.0	2	199997	8.00	1.126	0.675	0.141	1.0.2	2
165833	8.39	1.289	0.813	0.185	5.6.0	2	201409	7.60	1.160	0.800	0.214	1.3.3	2
166148	8.19	1.186	0.746	0.181		1							

the distance of the half dozen B type stars mentioned above. The star members in Tables 4 and 5 are from Lynga (1962).

M25: This cluster contains the Cepheid U Sgr. The B stars in the cluster give a modulus of 8.95 ± 0.35 mag (Eggen 1988) and this agrees with that obtained from DDO photometry for HD 170820. This star is a spectroscopic binary, $P=2323$ d (Mermilliod *et al.* 1987). If the companion is of early type it could vitiate the ultraviolet component of the combined light and explain the abnormally low luminosity from 4 color photometry. HD 170886 has the same radial velocity as 170820 and U Sgr but the modulus and reddening indicate a position in front of the cluster.

ADS 6988: HR 3475/4= ι Cnc, separated by 30 arcsec and with a common proper motion and radial velocity. The B component is of type A3 V and the luminosity and reddening are from the 4 color and $H\beta$ photometry (Eggen 1989a).

HR 3300AB: The components are separated by 86 arcsec and show a common proper motion and radial velocity, although the companion, an A2 V star, has a velocity range of at least 40 km/s.

ADS 15764: The faint companion, A3 V, is 29 arcsec distant and has a common proper motion with the red giant.

The agreement between the mean modulus obtained for the BG and SG in Table 4 and that of the accompanying cluster or binary members is GK stars - BA stars = -0.04 ± 0.14 mag. Also the reddening determinations from Eq. (10) agree well with those for the early type stars. An additional test of the reddening values is available for long period Cepheids (LPC, $P > 10$ d) which lie just outside the temperature range discussed here. Dean (1987) has published DDO photometry for these LPC;

TABLE 3. Corrections to Table 1, Paper I.

Name	For	Read
+55.2.5	+55.2.5	+55.215
66604	66604	66678
66678	66678	66604
6724318	6724318	67243A
91269	b-y = 0.963	0.463
93807	M ₁ = 0.619	0.614
98386	C ₁ = 0.672	0.363
-64.1193	-64.1993	-64.1943
14855	14855	114855
1553029	1553029	LSS 3029
128428	b-y = 0.29	0.267
	M ₁ = 0.267	0.290
	C ₁ = 0.290	0.841
	C ₁ = 0.015	0.315
131246	M ₁ = 0.224	0.274
148586	153523	153573
133523	v = 65V	6.65
160529	b-y = 0.628	0.637
192713	M ₁ = 0.391	0.286
	C ₁ = 0.339	0.353
211300A	v = 6.88	6.08

LPC	log P	R-I	45-48	42-45	$\delta(45-48)$	DDO	E(b-y) (4C)
RS Pup	1.617	0 ^m 565	1 ^m 440	0 ^m 925	0 ^m 190	0 ^m 321	0 ^m 349
T Mon	1.432	0.420	1.350	0.850	0.145	0.182	0.171
VY Car	1.277	0.425	1.340	0.830	0.147	0.200	0.219
SV Mon	1.180	0.385	1.280	0.760	0.129	0.188	0.196
V340 Nor	1.054	0.450	1.262	0.716	0.107	0.242	0.254

The available DDO photometry is phased with (*UBVRI*) photometry (Eggen 1983) and the values of (45-48) and (42-45) read at quarter phase (0^p25) are listed. The values of R-I at the same phase are from Eggen (1985). The reddening values from Eq. (10) give a mean difference of -0.011 ± 0.016 mag when compared with the values obtained from 4 color photometry (Eggen 1985) and, considering the scarcity and uncertainty of the DDO data, this is reassuring agreement.

TABLE 4. Clusters and wide binaries.

HD No.	$E(b-y)$	$(R-I)_0$	$(C_m)_0$	$\delta(45-48)_0$	$\delta(u-b)$	V_0	M_V DDO	M_V 4C	MOD
NGC 2287									
49068	0 ^m 035	0 ^m 403	0 ^m 266	0 ^m 017	0 ^m 050	7 ^m 30	-2 ^m 17	-1 ^m 96	9 ^m 36
49105	0.014	0.358	0.246	0.003	0.072	7.68	-1.64	-1.56	9.28
49212	<u>0.039</u>	0.373	0.244	0.004	0.038	7.66	-1.87	-1.46	<u>9.32</u>
mean	0.024								9.32
BA stars	0.018	± 0.015		Eggen (1981)				9.35	
NGC 2516									
HR 3076	0.090	0.351	0.346	0.021	0.121	6.36	-1.90	-1.86	8.24
BA stars	0.084	± 0.020		(Eggen and Iben 1991)				8.32	
NGC 3114									
119	0.072	0.342	0.202	0.047	0.138	7.37	-2.30	-1.90	9.47
159	0.074	0.326	0.175	0.036	0.081	8.18	-1.85	-1.29	9.75
184	<u>0.078</u>	0.321	0.164	0.055	0.169	7.47	-2.22	-1.90	<u>9.53</u>
mean	0.075								9.60
B stars	0.060	± 0.006		(Table 5)				9.70	
M25									
170886	0.293	0.296	0.022	0.086	0.212	5.76	-2.43	-1.97	(7.96)
170820	0.357	0.320	0.078	0.107	0.044	5.86	-3.19	(-0.95)	9.04
B stars	0.360	± 0.024		(Eggen 1988)				8.95	
ADS 6988									
74739	0.024	0.313	0.175	0.001	0.055	3.92	-0.97	-0.94	4.88
74738	0.019		$\beta = 2.910$			6.50		+1.32	5.18
HR 7300AB									
180262	0.014	0.327	0.212	-0.010	0.025	5.49	-0.95	-0.87	6.40
180243	0.035		$\beta = 2.905$			7.56		+1.30	6.26
ADS 15764									
211300A	0.033	0.339	0.300	-0.018	0.025	5.94	-0.94	-0.97	6.90
211300B	0.033		$\beta = 2.882$			8.32		+1.39	6.93

The color–luminosity array for the bright stars in the three clusters is shown in Fig. 1 where the isochrones represent stellar models of solar composition and convective overshoot at the cores (Bertelli *et al.* 1992). The bulk of the cluster stars are represented by isochrones from a little over

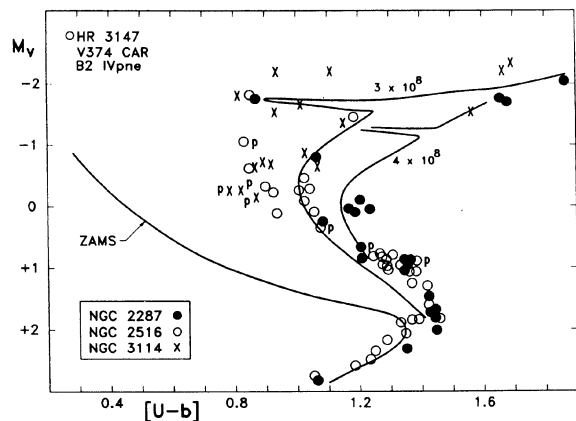


FIG. 1. Color–luminosity array for three clusters with bright giants. The isochrones are based on stellar models, with overshoot at the core.

4×10^8 yr to a little less than 3×10^8 yr, except for a clump of stars with $[u-b]$ between 0.75 and 0.95 mag and M_V between 0 and -1 mag. One half of these later stars are peculiar(si) objects and are labeled “p” in the figure. These stars are either younger than the bulk of the other cluster members, or the dominate peculiarity, Ap(si), is creating enhanced ultraviolet flux because of backwarming effects of the line blocking in the visual region. The latter is probably the case, with the enhanced u causing a diminished $[u-b]$, but this leaves unexplained the fifty percent of the objects that are not known to be Ap stars. For example, Nos. 13, 14, and 136 in NGC 3114 (Table 4) are B9 IV stars and $\Delta\alpha$ photometry (Maitzen *et al.* 1988), which is designed to distinguish such objects, does not isolate the last two stars. In the case of the brightest star in NGC 2516, there is no question that it appears younger than the other cluster members and this is almost certainly because of delayed evolution caused by matter exchange with a very close companion. An almost identical star, θ Car, with $[u-b]=0.011$ mag and $M_V=-3.65$ mag, in the cluster NGC 2602 (Eggen & Iben 1988, Fig. 8) bears the same relation to the other cluster members as HR 3147 in Fig. 1. θ Car is a spectroscopic binary with a period of 1.8 d and a very complex spectrum

TABLE 5. Photometry of early type stars in NGC 3114 (Schmidt 1982).

No.	E(b-y)	[u-b]	V_o	M_V	MOD	Sp. T.
3	0.058	0.929	7.49	-2.13	9.62	B8 III
4	0.060	1.085	7.58	-1.90	9.48	B9 III
6	0.055	1.000	8.06	-1.68	9.74	B9 IV
9	0.058	0.800	8.00	-1.59	9.59	B3 V
11	0.060	1.126	8.46	-1.47	9.93	B9 IV
13	0.061	0.897	8.93	-1.04	9.97	B9 IV
14	0.065	0.853	9.00	-0.96	9.96	B9 IV
102	0.070	1.022	8.81	-0.60	9.41	--
136	0.071	0.861	9.03	-0.61	9.64	--
149	0.052	0.924	8.22	-1.52	9.74	B9 III
183	<u>0.058</u>	1.080	9.08	-0.27	<u>9.35</u>	B9 V
mean	0.060				9.70	
σ	± 0.006				± 0.21	
16		0.816	9.38	(-0.32)		B9(S1)
18		0.856	9.56	(-0.14)		B8(S1)
61		0.776	9.46	(-0.24)		B8(S1)

with nitrogen enhancement and carbon deficiency. The spectrum of HR 3147(V3741 Car) in the cluster NGC 2516 (Fig. 1) is strikingly similar to that of θ Car, although the variable radial velocity has not been followed consistently enough to provide an orbital solution.

2. REDDENING, LUMINOSITY, AND SPACE MOTION OF THE NEAREST BRIGHT GIANTS AND SUPERGIANTS

Ninety-nine BG and SG with available photometry and apparent motions are listed in Table 6. The reddenings are from Eq. (10) and the luminosities from Eqs. (12) and (13). The proper motions are on the FK5 system. Using the stars classified by Keenan & McNeil (1989) as standards, the $[u-b]$, $(R-I)_0$ grid in Fig. 2 has been calibrated for spectral types and luminosity class and the resulting photometric estimates are listed in Table 5 as Sp.T.(COMP). The observed classifications are mainly from Keenan & McNeil (1989) and the Bright Star Catalogue (Hoffleit 1982). The

mean difference in the computed luminosities is M_V (DDO) $-M_V(4C) = -0.04 \pm 0.20(\sigma)$ mag. The weighed mean luminosity is used to construct the color-luminosity array of Fig. 3 where the stars of Table 5 are represented by clear circles. The isochrones are from solar abundance models with convective overshoot at the cores (Bertelli *et al.* 1992). The most notable feature of Fig. 3 is the scarcity of stars between 5×10^8 yr and the upper luminosity limit of class III stars at 10^9 yr (Eggen 1994). This age span is equivalent to about 2.5 to 5×10^8 yr in standard models or, roughly, the age of M11 to that of the Hyades.

Figure 4 (clear circles) shows the distribution of the BG and SG in the (U, V) plane, where U and V are directed, respectively, away from the galactic center and in the direction of galactic rotation, and the enclosed region is the domain of the young disk stars (e.g., Eggen 1989c). The mean values of U , V , and W in Table 5, compared with those for the complete samples of HR stars in the young disk and old disk populations (Eggen 1993), are;

		N	Age	U	σ	V	σ	W	σ
BG+SG	Young disk	93	$\leq 5 \times 10^8$ yr	+10.6	± 12.3	-13.2	± 8.8	-7.7	± 8.8
GK(III)	Young disk	220	$1-2 \times 10^9$ yr	+17.6	± 18.4	-14.8	± 8.4	-6.9	± 13.9
GK(III)	Old disk	350	$2-10 \times 10^9$ yr	+3.6	± 38.4	-20.2	± 27.5	-6.7	± 17.3

The consistent value of -7 km/s for W probably represents the $+7$ km/s velocity of the Sun with respect to the galactic plane. Perhaps the best estimate of the (U, V) velocity of the Sun with respect to the center of rest is obtained from the young disk stars, age 1 to 2×10^9 yr, or $(-17.5, +15)$ km/s. The values for the BG and SG may be influenced by group motions amongst recently formed stars, although such group, or supercluster motions, can also influence the mean values of the young disk stars in general.

3. METALLICITY

The values of $P[\text{Fe}/\text{H}]$ derived from Eq. (7) for some 100 disk stars (luminosity class III) give a dispersion of about ± 0.10 dex (Eggen 1993, 1994) when compared with the $[\text{Fe}/\text{H}]$ values derived from high dispersion spectroscopy (McWilliam 1990). Model atmospheres indicate that the metallicity index, M_1 , is sensitive to luminosity (gravity) effects so the values for the BG and SG stars need normalization.

TABLE 6. Reddening, luminosity, and space motion of BG and SG near the Sun.

HD	E(b-y)	(R-I) ₀	(C _m) ₀	δ(45-48) ₀	δ(u-b) ₀	V ₀	M _V	4C	μ _l /μ ₀	ρ	U	V	W	HR	COMP	Sp.T.	OBS	Note
			(-1-11)				000		0 ^m 001	km/sec	km/sec	km/sec	km/sec					
3712	0 ^m 034	0 ^m 359	0 ^m 372	0 ^m 029	0 ^m 135	2 ^m 08	-2 ^m 18	-2 ^m 04	53/-32	-3.6	+11.2	-13.0	-10.4	168	K0 II		K0 IIIa	
5575	0.022	0.335	0.297	0.005	0.022	5.33	-1.36	-0.93	8/-8	-0.5	+4.4	-8.4	-5.8	274	K0 II-III			
8267	0.040	0.307	0.245	0.006	0.086	7.90	-1.00	-1.12	3/-2	-1.8	+9.9	+0.4	-3.5		G6/8 II-III			
9270	0.032	0.300	0.225	0.004	0.063	3.51	-0.86	-0.88	28/-5	+14.4	+15.0	-0.9	-10.0	437	G6/8 II-III		G7 IIIa	X
11763	0.063	0.367	0.360	0.007	0.049	5.49	-1.76	-1.48	9/-6	+13.6	+15.1	-5.0	-10.5	559	K0 II		K1 III	X
12270	0.029	0.282	0.174	-0.001	0.069	6.24	-0.50	-0.73	(-31/-12)	+12.0	(-19.0)	-6.0	-5.0	584	G5 II-III		G8 II-III	X
16161	0.036	0.271	0.151	-0.003	0.026	4.71	-0.30	-0.29	-26/-25	+6.0	+3.0	+0.6	-15.5	754	G5 II-III		G8 III	X
16307	0.000	0.332	0.320	-0.003	0.053	5.75	-1.16	-1.14	-12/-3	+2.4	-8.6	+6.0	-8.4	767	G6/8 II		G8 III	
20894	0.021	0.284	0.155	-0.009	0.020	5.42	-0.37	-0.38	-23/-28	+8.1	+17.1	-5.8	-14.8	1016	G5 II-III		G6.5 II	X
21754	0.014	0.357	0.338	0.006	0.060	4.06	-1.69	-1.45	20/-2	+14.7	-17.7	-7.2	-2.0	1066	K0 II-III		K0 II-III	X
25877	0.166	0.291	0.230	0.028	0.158	5.58	-1.20	-1.50	-18/-8	-14.0	-14.6	+0.6	-21.9	1270	G6/8 II		G8 II	
27256	0.027	0.285	0.203	-0.003	0.085	3.25	-0.50	-0.88	44/-45	+35.6	+15.0	-32.0	-18.6	1336	G5 II-III		G8 II-III	
28100	0.043	0.299	0.215	0.002	0.061	4.52	-0.80	-0.85	13/-30	+31.8	+27.0	-17.9	-17.1	1396	G6/8 II-III		G7 IIIa	X
31767	0.039	0.443	0.452	0.024	0.100	4.31	-2.94	-2.66	-4/-3	+14.5	+10.0	-3.5	-12.0	1601	K2 II		K2 II	
34033	0.099	0.308	0.239	0.003	0.062	8.25	-0.94	-0.95	-1/-10	+43.4	+32.0	-30.0	-30.1		G6/8 II-III			
36597	0.018	0.377	0.361	0.000	0.060	3.60	-1.83	-1.66	23/-33	-4.9	-17.9	-10.2	+9.3	1862	K1 II-III		K1 IIIa	
39400	0.061	0.425	0.393	0.036	0.129	4.52	-3.00	-2.77	-10/-9	+10.4	+4.0	+6.4	-20.3	2037	K1 Ib		K1.5 Ib	
39775	0.019	0.433	0.450	0.018	0.092	5.92	-2.72	-2.50	-7/0	+21.7	+19.9	-12.4	-18.9	2057	K1 II		K0 II	
40733	0.021	0.327	0.289	0.008	0.056	5.75	-1.31	-1.11	-10/6	+12.0	+10.8	-2.6	-14.4	2117	K0 II-III		G8 II	
40808	0.025	0.352	0.390	0.020	0.119	3.86	-1.96	-1.85	22/-14	+17.0	-4.6	-23.8	+3.0	2120	K0 II		K0 III	
41361	0.034	0.313	0.274	0.017	0.089	5.54	-1.29	-1.21	-10/-4	+19.9	+17.2	-5.7	-14.4	2144	G6/8 II-III			
41380	0.052	0.291	0.227	0.029	0.123	5.62	-1.22	-1.24	1/-5	+33.2	+28.2	-16.2	-8.0	2145	G6/8 II		G4 III	
42351	0.026	0.430	0.214	0.014	0.089	6.27	-2.62	-2.44	(5/-10)	-2.6	-8.9	-28.5	-1.8	2184	K1 II		K1 II	
45416	0.030	0.352	0.448	0.028	0.179	5.08	-2.06	-2.30	0/-11	+32.8	+21.0	-28.4	-8.7	2334	K1 Ib		K0 Ib	X
45829	0.116	0.381	0.325	0.109	0.317	6.12	-4.00	-3.66	1/-7	0.0	-12.0	-27.5	-10.8		K1 Ib		K0 Ib	
47475	0.030	0.332	0.304	0.031	0.122	6.23	-1.84	-1.66	3/1	+13.8	+5.0	-14.1	+0.8	2445	K0 II		G5 Ib	
47731	0.070	0.295	0.216	0.040	0.184	6.15	-1.50	-1.75	0/-2	-6.1	-6.0	-2.3	-2.5	2453	G6/8 Ib-11		G5 Ib	
48329	0.073	0.362	0.388	0.103	0.336	2.71	-3.70	-3.50	-5/-13	+9.1	+9.0	-9.7	-7.4	2473	K0 Ib		G8 Ib	
50337	0.025	0.297	0.015	4.32	...	-0.48	-8/17	+25.5	+10.4	-22.7	-9.3	2554	G6/8 II-III		G6 II	X
50890	0.054	0.323	0.297	0.023	0.078	5.80	-1.55	-1.23	-11/-4	+13.8	+16.9	-9.8	-15.2	2582	G6/8 II-III		G5 Ib-11	X
51043	0.051	0.297	0.230	0.037	0.146	6.34	-1.47	-1.48	-8/11	+13.8	+27.2	-7.7	-12.1	2587	G6/8 II		G5 Ib-11	X
52497	0.044	0.271	0.152	0.024	0.076	5.01	-0.80	-0.67	-9/-6	-9.0	-7.0	+3.2	-7.4	2630	G5 II		G5 II-1b	
54732	0.008	0.311	0.258	0.001	0.083	5.93	-0.94	-1.15	(-9/42)	+29V	(+54.0)	-23.0	-2.0	2698	G6/8 II-III		K0 III	X
55070	0.028	0.295	0.266	0.014	0.089	5.35	-0.98	-1.02	-10/1	+15.0	+11.0	-9.3	-9.6	2708	G6/8 II-III		G8 III	X
57478	0.055	0.287	0.179	0.005	0.050	5.37	-0.69	-0.64	-17/-1	+13.2	+12.6	-6.5	-11.4	2796	G6/8 II-III		G8 III	
58367	0.046	0.292	0.207	-0.019	0.071	4.81	-1.04	-0.86	-3/-10	-7.8	-8.0	-1.5	-7.6	2828	G6/8 II-III		G6 II	
59669	0.028	0.349	0.329	0.033	0.104	6.15	-2.10	-1.70	-4/-4	+17.0	+11.3	-14.4	-8.2	2876	K0 II			

TABLE 6. (continued)

HD	E(b-y)	(R-I) ₀	(C _m) ₀ (1-11)	δ(45-48) ₀	δ(u-b) ₀	V ₀	M _v 000	4C	M _a /M _s 0 ⁰⁰⁰¹	ρ km/sec	U	V km/sec	W	HR	COMP	Sp.T.	OBS	Note
64320	0.090	0.351	0.346	0.021	0.121	6.36	-1.90	-1.86	2/14	+22.0	+23.3	-27.0	-10.0	3076	K0 II		K0 II	
65699	0.048	0.300	0.259	0.038	0.164	4.89	-1.53	-1.65	-17/-2	+11.4	+11.5	-7.5	-13.2	3123	G6/8 II		K0 Ib-II	
66190	0.046	0.343	0.367	0.068	0.254	6.44	-2.73	-2.78	-1/-4	+26.9	-4.9	-26.6	-12.9	3146	K0 Ib		K1 Ib-II	X
67249	0.140	0.288	0.298	0.076	0.251	5.36	-2.12	-2.18	5/3	+26.7	+10.2	-24.7	-9.0	3178	G6/8 Ib		G5 II	
67447	0.042	0.295	0.240	0.023	0.153	5.14	-1.16	-1.51	0/8	-9.6	+10.3	+2.0	-6.0	3182	G6/8 II		G7 II	
68752	0.033	0.320	0.233	0.015	0.031	4.88	-1.35	-1.15	-13/-4	+16.2	+11.8	-13.4	-7.7	3229	G6/8 II-III		G5 Ib/II	
69478	0.021	0.301	0.245	0.007	0.098	6.20	-0.92	-1.16	-18/-9	+28.9	+30.6	-21.8	-14.1	3252	G6/8 II-III		G8 II	X
71115	0.036	0.291	0.193	-0.005	0.057	4.96	-0.54	-0.74	-34/-12	+14.5	+19.5	-11.3	-14.1	3306	G6/8 II-III		G8 II	X
72561	0.041	0.315	0.272	0.020	0.096	5.72	-1.38	-1.28	-14/-11	+0.7	+4.7	-9.2	-19.2	3378	G6/8 II		G5 III	X
73155	0.049	0.409	0.409	0.024	0.087	4.79	-2.61	-2.31	-7/16	+4.4	+21.7	-3.4	+0.1	3407	K1 II		K1.5 Ib-II	
74739	0.024	0.313	0.238	0.001	0.054	3.52	-0.97	-0.94	-25/-42	+16.0	+16.9	-20.9	-2.9	3475	G6/8 II-III		G8 II-III	X
76219	0.046	0.307	0.243	0.001	0.057	5.00	-0.89	-0.91	-12/-32	+17.1	+12.9	-22.8	+3.3	3540	G6/8 II-III		G8 II-III	X
76494	0.026	0.311	0.246	0.002	0.074	6.03	-0.97	-1.08	1/-4	+12.2	+4.7	-11.3	+4.9	3557	G6/8 II-III		G8 II-III	
77020	0.032	0.324	0.295	0.014	0.085	5.96	-1.39	-1.30	-23/6	+17.5	+25.3	-16.4	-17.6	3583	K0 II		G8/K0 II	
77615	0.118	0.335	0.311	0.033	0.119	5.31	-1.92	-1.67	-11/4	+18.0	+9.7	-18.4	-9.6	3604	K0 II		G8 II	
77912	0.038	0.303	0.245	0.019	0.125	4.40	-1.20	-1.38	-28/-14	+16.6	+24.2	-9.8	-2.8	3612	G6/8 II		G7 Ib-II	
79846	0.025	0.305	0.260	-0.007	0.094	5.17	-0.70	-1.16	-31/20	+8.8	+29.0	-10.8	-9.2	3679	G6/8 II-III		G8 II-III	X
80126	0.045	0.305	0.227	0.014	0.060	6.13	-1.12	-0.91	-16/6	+14.3	+43.2	-17.6	-22.8	3693	G6/8 II-III		G8 II	
85656	0.070	0.376	0.405	0.037	0.155	5.25	-2.56	-2.38	-6/9	+12.0	+13.9	-15.9	+3.8	3914	K1 Ib/II		K0 III	
92449	0.032	0.292	0.207	0.025	0.148	4.14	-1.16	-1.44	-20/-4	+20.0	+3.1	-21.8	-6.4	4180	G6/8 II		G3 Ib	X
93807	0.060	0.361	0.374	0.054	0.195	6.86	-2.70	-2.52	(2/-15)	-1.0	(-30)	+8:	-50:		G5 Ib		G8 Ib	X
101570	0.130	0.280	0.147	0.057	0.207	4.40	-1.63	-1.76	-5/-16	+13 Var	(-5)	-12:	+13:	4499	G5 Ib		G3 Ib	
102839	0.170	0.317	0.262	0.088	0.291	4.22	-2.77	-2.79	-12/0	+18.2	+4.0	-22.0	-5.8	4538	K0 Ib		G6 Ib	
105138	0.100	0.316	0.196	0.068	0.250	5.81	-2.29	-2.47	(-7/18)	+6.0	(+14)	-18:	+33:	4614	G6/8 Ib		G3 Ib	
111790	0.040	0.319	0.264	0.027	0.093	5.61	-1.58	-1.31	(-15/-5)	-23.0	(+26)	+8:	-10:	4882	G6/8 II		G8 Ib-II	
115004	0.002	0.340	0.340	-0.002	0.076	4.94	-1.29	-1.40	-49/14	-21.9	+40.7	-20.3	-19.7	4997	K0 II-III		G8.5 IIIa	X
118520	0.106	0.294	0.196	0.041	0.141	6.31	-1.51	-1.41	-2/-15	-10.0	+11.3	-1.2	+24.3	5124	G6/8 Ib		G5 Ib	
125809	0.090	0.320	0.284	0.074	0.217	6.03	-2.53	-2.26	-7/-16	0:	+13.0	-23.9	-27.0		G6/8 Ib		G8 Ib	
128713	0.050	0.349	0.329	0.004	0.044	6.12	-1.54	-1.25	-17/16	+5.0	+6.8	-12.0	+32.0	5461	K0 II-III		K0/1 II	X
131246	(0.100)	0.345	--	--	0.139	5.24	--	-1.93	(-8/-8)	-21:	(+23)	+5:	+4:		K0 II		G8 Ib	X
131425	(0.050)	0.310	--	--	0.065	5.72	--	-1.0	-7/-12	+1.9	+9.8	-7.8	-7.7	5547	G6/8 II-III		G8 II	
137465	0.062	0.281	0.180	0.045	0.150	5.84	-1.40	-1.34	-6/-7	-16.4	+19.9	-1.6	-4.2	5738	G5 II		G2 II	
141767	0.101	0.297	0.262	0.040	0.176	4.68	-1.53	-1.71	-4/-5	+6.0	-0.6	-7.9	-2.2	5891	G6/8 II		G5 II	
145544	0.084	0.292	0.270	0.057	0.191	3.48	-1.80	-1.76	+2/-11	-4.7	+6.4	+0.4	-4.3	6030	G5 Ib-II		G2 Ib-II	
150030	0.000	0.325	0.282	0.000	--	5.74	-1.12	--	-11/4	-14.7	+10.7	-16.7	-0.7	6183	G6/8 II		G8 II	
150416	0.112	0.299	0.218	0.027	0.103	4.48	-1.30	-1.17	-20/-1	-25.2	+26.8	-8.4	+0.8	6196	G6/8 II-III		G7.5 II-III	X
156768	0.056	0.306	0.264	0.017	0.112	5.63	-1.20	-1.31	-7/-19	-10.0	+19.9	-15.1	-3.1	6438	G6/8 II		G8 Ib-II	

TABLE 6. (continued)

HD	E(b-y)	(R-I) ₀	(C _m) ₀	δ(45-48) ₀	δ(u-b) ₀	V ₀	M _V	4C	M _a /M _s	ρ	U	V	W	HR	COMP	Sp.T.	OBS	Note
			(1-11)				DOO		0 ⁺ 001	km/sec	km/sec	km/sec	km/sec					
157819	0.030	0.327	0.298	0.015	0.071	5.83	-1.45	-1.22	-5/-13	-12.6	+19.1	-10.7	-1.1	6487	K0 II-III	G8 II-III		
159633	0.100	0.328	0.224	0.070	0.195	5.85	-2.56	-2.18	3/-3	+12.0	-11.0	-4.0	-8.8	6557	K0 Ib	G3 Ib		
160635	0.000	0.387	0.402	0.002	0.084	3.62	-1.97	-1.95	-15/-54	-7.6	+26.0	-24.0	-4.8	6582	K1 II	K2 II		
161664	0.378	0.295	0.210	0.091	0.275	4.80	-2.52	-2.44	-3/-7	-27.8	+26.5	-13.6	-3.0	6617	G6/8 Ib	G6 Ib		
164349	0.050	0.375	0.384	0.025	0.120	4.44	-2.32	-2.10	-7/-10	-23.4	+8.4	-24.6	-5.4	6713	K1 II	K0.5 II		
166063	0.025	0.312	0.262	0.005	0.059	4.42	-1.04	-0.97	-17/-37	-26.3	+30.4	-17.4	+4.8	6783	G6/8 II-III	G8 III		
170886	0.304	0.285	0.124	0.091	0.254	5.71	-2.38	-2.17	3/-4	+0.1	-0.9	-4.2	-8.1	7063	G5 Ib	G3/5 Ib		
173764	0.120	0.280	0.205	0.042	0.173	3.71	-1.33	-1.50	-4/-16	-21.5	+15.0	-17.5	-1.3	7114	G5 Ib-II	G5 IIa		X
174947	0.117	0.321	0.286	0.045	0.164	5.20	-1.96	-1.87	6/-16	+9.0	+7.6	-17.0	-13.5	7164	G6/8 II	K1 Ib		
176123	0.095	0.270	0.114	0.023	0.067	5.99	-0.81	-0.60	0/-18	-15.0	+10.5	-20.8	-5.3	7164	G5 II-III	G5/6 II		
178345	0.064	0.334	0.344	0.041	0.134	3.82	-2.07	-1.78	10/-37	+2.7	+3.1	-20.9	-14.6	7259	K0 II	K0 II		
180540	0.016	0.306	0.234	0.012	0.087	4.81	-1.09	-1.12	-12/-14	+15.2	-18.7	-6.9	-0.6	7304	G6/8 II-III	G8 II-III		
180809	0.047	0.378	0.372	0.034	0.144	4.16	-2.52	--	-1/4	-27.5	+12.0	-24.8	-3.1	7314	K1 II	K0 II		
185958	0.026	0.318	0.294	0.011	0.144	4.29	-1.33	-1.68	10/-32	-22.4	+0.2	-28.5	-16.3	7488	G6/8 II	G8 IIIa		
198308	0.036	0.367	0.302	-0.013	0.040	4.93	-1.45	-1.55	1/-10	+21.4	-13.9	-13.1	-13.6	7968	K1 II-III	K1 II-III		
198700	0.025	0.361	0.401	0.044	0.193	3.50	-2.50	-2.50	16/-26	-4.9	+17.0	-17.0	-4.0	7986	K1 II	K1 II		
199253	0.061	0.335	0.275	0.009	0.122	4.91	-1.44	-1.69	20/-14	-9.0	+8.2	-13.8	-17.9	8011	K0 II	K0 II		
206834	0.025	0.319	0.320	0.032	0.161	4.99	-1.68	-1.83	18/-2	-6.7	+16.0	-6.2	-9.9	8311	G6/8 II	G7.5 II-III		
206859	0.081	0.309	0.267	0.057	0.212	4.02	-2.04	-2.10	11/-10	-22.6	+8.2	-24.0	-0.2	8313	G6/8 Ib	G5 Ib		
207089	0.130	0.352	0.307	0.072	0.227	4.72	-2.94	-2.67	15/-7	-11.0	+13.0	-16.6	-17.6	8321	K0 Ib	K0 Ib		
210745	0.121	0.409	0.407	0.109	--	2.80	-6.41	--	15/4	-17.2	+5.0	-18.7	-3.8	8465	K1 Ib	K1.5 Ib		
210807	0.034	0.278	0.174	0.007	0.063	4.64	-0.60	-0.65	32/3	-14.5	+9.3	-16.6	-11.8	8468	G5 II-III	G7 II-III		
211053	0.016	0.323	0.272	-0.004	0.076	6.07	-1.01	-1.22	1/-4	-4.3	+3.0	-5.0	+3.6	8484	G6/8 II-III	G8 III		
216206	0.103	0.288	0.201	0.046	0.169	5.78	-1.52	-1.56	9/4	-9.4	+15.8	-15.1	-9.8	8692	G5 II	G4 Ib		
223047	0.112	0.271	0.207	0.062	0.188	4.48	-1.60	-1.52	11/-5	-22.6	-1.8	-24.5	+6.3	9003	G5 Ib-II	G3 Ib-II		

Notes to TABLE 6.

11763 RR Ari, not variable.
 12270 The proper motion needs strengthening.
 16161 An F7V star 8 arcsec distant has (V, B-V) = (9.08, 0.56) mag, or a modulus of 4.8 mag, agreeing well with that obtained for the BG.
 20894 Keenan and McNeil (1989) call the spectral type G6.5 IIb CN-1M6 -1.
 21754 Sp.B., P = 960d. Keenan and McNeil (1989) call the spectral type K0 II-III Fe-0.5.
 47475 Mistakenly labeled HD43745 in Eggen (1992).
 50337 Sp.B., P = 195.3d.
 50890 C1 = 0.361 not 0.403 mag as printed in Eggen (1989b).
 54732 The proper motion is very poorly determined and the radial velocity is variable.
 55070 The radial velocity depends upon a single measurement.
 66190 b-y = 0.764 not 7.764 mag as misprinted in Eggen (1989b).

TABLE 6. (continued)

71115	11.24 mag star 30 arcsec distant ($\beta = 2.600$) has a modulus of 6.67 mag and is apparently an optical companion only.
72561	$b-y = 0.654$, $M_1 = 0.448$, $C_1 = 0.375$ mag are misprinted in Eggen (1989b).
74739	Common proper motion with 74738.
79846	Revised values of $b-y = 0.602$, $M_1 = 0.394$, and $C_1 = 0.404$ mag from 6 observations.
92449	HD 92463, a 88V star with $V = 6.25$ mag is 52 arcsec distant ($\beta = 2.740$). The photometry gives a reddening of $E(b-y) = 0.030$ mag and a modulus of 6.8 mag so the star is an optical companion only.
93807	$M_1 = 0.614$ misprinted as 0.619 mag in Eggen (1989).
118520	Equal component binary, 0.1 arcsec separation.
131246	The radial velocity depends upon a single measurement. The value of $C_1 = 0.315$ is misprinted as 0.015 mag in Eggen (1992).
150416	Ba 0.5 Keenan and McNeil (1989).
173746	Sp.B., $P = 834d$.
198308	$b-y = 0.690$, $M_1 = 0.509$ and $C_1 = 0.400$: mag. Incorrect in Eggen (1993).
223047	McAlister No. 75 (McAlister and Hartkopf 1988) with a separation of 0.14 arcsec.

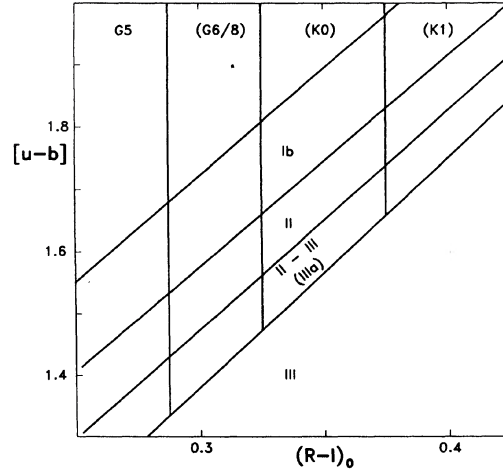


FIG. 2. Spectral type and luminosity class grid in the $([u-b], R-I)$ plane.

The mean correlations of $(M_1)_0$ and $[u-b]$ with $(R-I)_0$ lead to

$$\Delta(M_1)_0 = 0.676\Delta[u-b] - 0.050,$$

giving for the luminosity corrected values of $(M_1)_0$,

$$(M_1)_0 = 0.676[u-b] - 0.50(R-I)_0 - 0.427 \quad (14)$$

and the values of $(M_1)_0$, observed and computed from Eq. (14), are listed in Table 7. Excluding the stars HD 42351, 67249, 105138, and 223047, the mean difference is $-0.004 \pm 0.014(\sigma)$ mag. Evidently the values of M_1 are reflecting luminosity alone unless the BG and SG stars all have essentially the same metallicity, with a dispersion of only 0.04 dex. McWilliam (1990) and Luck & Bond (1989) have derived $[Fe/H]$ values from high dispersion spectroscopy for the stars listed in Table 8 and they range from -0.38 to $+0.38$ dex.

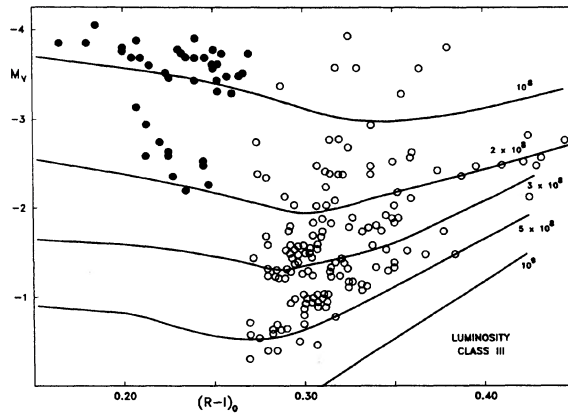


FIG. 3. The GK stars (open circles) and G0/3 stars (closed circles) in the $(M_v, R-I)$ plane. The isochrones are based on stellar models with overshoot at the core.

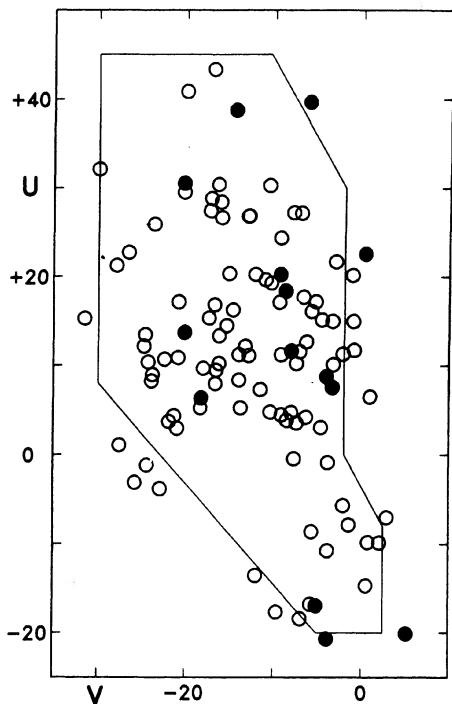


FIG. 4. The GK (open circles) and G0/3 (closed circles) stars in the (U, V) plane. The outlined area is the domain of the young disk population.

Most of the stars in Table 7 have available Geneva photometry (Rufener 1988), where the equivalent indices to M_1 and $[u-b]$ are m_2 and Del, respectively. The mean relationships of m_2 and Del with $(R-I)_0$ are

$$m_2 = 1.95(R-I)_0 - 0.770$$

$$\text{Del} = 3.95(R-I)_0 - 0.740,$$

and correlating $\Delta m_2 = m_2(\text{obs}) - m_2(\text{comp})$ with $\Delta \text{Del} = \text{Del}(\text{obs}) - \text{Del}(\text{comp})$ gives

$$\Delta m_2 = 0.55 \Delta \text{Del} \quad \text{or} \quad m_2 = 0.55 \text{Del} - 0.227(R-I)_0 - 0.353. \quad (15)$$

The observed and computed (luminosity corrected) values of m_2 in Table 7 give $O-C = +0.004 \pm 0.011(\sigma)$ mag, and support the results for M_1 in that there is little evidence for other than a luminosity sensitivity in m_2 .

The temperatures adopted by McWilliam and by Luck and Bond are correlated with $(R-I)_0$,

$$\log T_e = 3.807 - 0.40(R-I)_0 \quad (16)$$

and this is used to compute the values in Table 8. With the exception of the two faintest stars, HD 62236 and 151834, which are not in Table 5 but are discussed in the next section, the temperature differences are less than about 200° and should not lead to errors greater than about ± 0.2 dex in $[\text{Fe}/\text{H}]$.

TABLE 7. Metallicity parameters for the stars in Table 5.

HD	OBS	$(M_1)_0$ COMP	O-C	OBS	m_2 COMP	O-C	ΔCN	$[\text{Fe}/\text{H}]$ ΔCN	X pc	HD	OBS	$(M_1)_0$ COMP	O-C	OBS	m_2 COMP	O-C	ΔCN	$[\text{Fe}/\text{H}]$ ΔCN	X pc
3712	0*544	0*568	-0*024	-0*069	-0*063	-0*006	+0*024	0.00	+35	77020	0.477	0.463	+0.014	-0.139	-0.156	+0.017	+0.014	-0.05	+6
5575	0.450	0.443	+0.007				-0.004	-0.14	+92	77615	0.513	0.509	+0.004	-0.120	-0.136	+0.016	+0.003	-0.11	-41
8267	0.429	0.428	+0.001				-0.003	-0.14	+181	77912	0.426	0.440	-0.014	-0.165	-0.163	-0.002	+0.004	-0.10	+102
9270	0.399	0.398	+0.001	-0.197	-0.190	-0.007	-0.010	-0.17	+38	79846	0.404	0.430	-0.026	-0.175	-0.173	-0.002	+0.016	-0.04	-15
11763	0.511	0.528	-0.017				-0.002	-0.13	+166	80126	0.406	0.407	-0.001	-0.180	-0.190	+0.010	-0.018	-0.21	-33
12270	0.362	0.365	-0.003	-0.225	-0.240	+0.012	-0.027	-0.25	-57	85656	0.617	0.618	-0.001	-0.023	-0.030	+0.007	+0.026	+0.01	-83
16161	0.316	0.314	+0.002	-0.273	-0.263	-0.010	-0.049	-0.36	+64	92449	0.410	0.439	-0.029	-0.187	-0.184	-0.003	-0.013	-0.18	-31
16307	0.444	0.457	-0.013	-0.128	-0.131	+0.003	+0.024	0.00	+66	93807	0.627	0.607	+0.020	-0.033	-0.046	+0.013	+0.023	0.00	-227
20894	0.326	0.336	-0.010	-0.249	-0.248	-0.001	-0.050	-0.37	+65	101570	0.424	0.454	-0.030	-0.212	-0.204	-0.008	-0.050	-0.32	-70
21754	0.509	0.514	-0.005	-0.101	-0.091	-0.010	-0.005	-0.14	+110	102839	0.579	0.576	+0.003	-0.099	-0.099	0.000	-0.005	-0.15	-116
25877	0.434	0.444	-0.010	-0.189	-0.179	-0.010	+0.012	-0.06	+199	105138	0.491	0.558	(-0.067)	-0.129	-0.128	-0.001	-0.069	-0.46	-207
27256	0.359	0.382	-0.023	-0.210	-0.209	-0.001	-0.004	-0.19	-3	111790	0.470	0.459	+0.011	-0.148	-0.162	+0.014	-0.007	-0.16	-138
28100	0.384	0.394	-0.010	-0.211	-0.196	-0.015	-0.018	-0.21	+108	115004	0.488	0.450	-0.002	-0.116	-0.125	+0.009	+0.029	+0.02	+11
31767	0.689	0.714	-0.025	0.041	0.050	-0.009	-0.055	-0.39	+230	118520	0.437	0.439	-0.002	-0.195	-0.197	+0.002	-0.028	-0.26	-226
34033	0.401	0.414	-0.013				-0.011	-0.18	+657	125809	0.536	0.544	-0.008				+0.011	-0.06	-356
36597	0.533	0.556	-0.023				-0.020	-0.22	+50	128713	0.460	0.487	-0.027	-0.136	-0.138	+0.002	+0.001	-0.12	-232
39400	0.691	0.701	-0.010	0.006	0.004	+0.002	-0.080	-0.52	+170	131246	0.555	0.543	+0.012	-0.106	-0.116	+0.010	--	--	-155
39775	0.673	0.692	-0.019	0.026	0.025	+0.001	-0.038	-0.31	+449	131425	0.429	0.420	+0.009	-0.176	-0.186	+0.010	--	--	-136
40733	0.455	0.450	+0.005	-0.133	-0.156	+0.023	+0.003	-0.11	+72	137465	0.436	0.418	+0.018	-0.223	-0.231	+0.008	-0.019	-0.21	-229
40808	0.534	0.550	-0.016	-0.086	-0.070	-0.016	+0.056	+0.16	+44	141767	0.495	0.469	+0.026	-0.148	-0.158	+0.010	+0.033	+0.04	-124
41361	0.464	0.443	+0.021	-0.152	-0.168	+0.014	+0.014	-0.05	+208	145544	0.475	0.469	+0.006	-0.154	-0.180	+0.026	+0.050	+0.13	-90
41380	0.439	0.421	+0.018	-0.184	-0.191	+0.007	+0.009	-0.07	+193	150030							0.000	-0.12	-35
42351	0.641	0.684	(-0.043)				-0.034	-0.29	+562	150416	0.426	0.423	+0.003	-0.200	-0.209	+0.009	-0.015	-0.18	-132
45416	0.576	0.584	-0.008	-0.049	-0.051	+0.002	+0.061	+0.19	+245	156788	0.442	0.444	-0.002	-0.179	-0.171	-0.008	+0.018	-0.03	-207
45829	0.727	0.739	-0.012	-0.011	0.008	-0.019	-0.012	-0.06	+896	157811	0.469	0.460	+0.009	-0.143	-0.165	+0.023	+0.012	-0.06	-243
47475	0.499	0.504	-0.005	-0.111	-0.124	+0.013	+0.008	-0.08	+126	159633	0.519	0.546	-0.027	-0.127	-0.133	+0.006	-0.064	-0.46	-445
47731	0.468	0.468	0.000	-0.170	-0.170	0.000	-0.010	-0.17	-82	160635	0.583	0.592	-0.009	-0.035	-0.041	+0.006	+0.002	-0.11	-106
48329	0.715	0.711	+0.004	0.002	0.012	-0.010	+0.035	+0.06	+178	161664	0.511	0.526	-0.015	-0.197	-0.170	-0.027	-0.030	-0.27	-284
50337	0.341	0.310	-0.019	-0.271	-0.244	-0.027	--	--	+10	166349	0.594	0.589	+0.005	-0.039	-0.051	+0.012	-0.004	-0.14	-149
50877	0.812	0.820	-0.008	0.074	0.125	(-0.051)	-0.150	(-0.87)	+205	166063	0.424	0.421	+0.003	-0.158	-0.177	+0.019	+0.004	-0.10	-116
50890	0.505	0.490	+0.015	-0.134	-0.154	+0.020	+0.018	-0.03	+222	170866	0.363	0.396	-0.033	-0.273	-0.271	-0.002	-0.064	-0.44	-381
51043	0.443	0.448	-0.005	-0.156	-0.170	+0.014	0.000	-0.12	+36	173764	0.438	0.436	+0.002	-0.229	-0.205	+0.024	-0.025	+0.01	-93
52497	0.361	0.372	-0.011	-0.233	-0.223	-0.010	-0.028	-0.26	+134	174947	0.512	0.510	+0.002	-0.145	-0.145	0.000	+0.011	-0.06	-254
54732	0.411	0.434	-0.023	-0.159	-0.162	+0.003	+0.002	-0.11	+81	178345	0.485	0.507	-0.022	-0.086	-0.106	+0.020	+0.044	+0.10	-133
55070	0.428	0.405	+0.023	-0.173	-0.186	+0.013	+0.040	+0.08	+93	180540	0.413	0.426	-0.013	-0.174	-0.184	+0.010	-0.012	-0.18	-140
57478	0.362	0.363	-0.001	-0.226	-0.230	+0.004	-0.031	-0.28	+106	180809							-0.011	-0.18	-73
58367	0.400	0.386	+0.014	-0.188	-0.180	-0.008	-0.011	-0.17	+122	185958	0.457	0.491	-0.033	-0.135	-0.129	-0.006	+0.025	+0.01	-84
59669	0.562	0.530	+0.032	-0.086	-0.100	+0.014	0.000	-0.12	+299	198308	0.516	0.531	-0.015	-0.094	-0.101	+0.007	-0.060	-0.42	-145
64320	0.528	0.530	-0.002	-0.099	-0.111	+0.012	-0.003	+0.14	-20	198700	0.613	0.613	0.000	-0.021	-0.034	+0.013	+0.050	+0.13	-117
65699	0.478	0.467	+0.011	-0.159	-0.162	+0.003	+0.024	0.00	+95	199253	0.514	0.511	+0.003	-0.100	-0.110	+0.010	-0.026	-0.25	-90
66190	0.635	0.617	+0.018	-0.042	-0.038	-0.004	+0.050	+0.13	+69	206834	0.495	0.503	-0.008	-0.108	-0.118	+0.010	+0.049	+0.12	-114
67249	0.561	0.500	(+0.061)	-0.122	-0.139	+0.017	+0.086	+0.31	+26	206854	0.524	0.517	+0.005	-0.121	-0.137	+0.016	+0.033	+0.04	-45
67447	0.435	0.448	-0.013	-0.169	-0.163	-0.006	+0.014	-0.05	+140	207089	0.638	0.617	+0.021	-0.042	-0.044	+0.002	-0.026	-0.25	-70
68752	0.419	0.418	+0.001	-0.183	-0.199	+0.016	-0.040	-0.32	+91	210745	0.647	0.639	+0.008	0.041	0.064	-0.023	-0.035	-0.30	+63
69478	0.420	0.424	-0.004	-0.185	-0.193	+0.008	+0.008	-0.08	+212	210807	0.333	0.352	-0.019	-0.243	-0.237	-0.006	-0.019	-0.22	+40
71115	0.373	0.376	-0.003	-0.212	-0.214	+0.002	-0.025	-0.25	+96	211053	0.428	0.454	-0.026	-0.157	-0.158	+0.001	-0.007	-0.15	-151
72561	0.460	0.465	-0.005	-0.140	-0.147	+0.007	+0.011	-0.07	+178	216206	0.442	0.445	-0.003	-0.190	-0.183	-0.007	-0.011	-0.18	+70
73155	0.623	0.633	-0.010	-0.001	-0.015	+0.014	-0.053	-0.39	+13	223047	0.474	0.422	(+0.054)	-0.210	-0.215	+0.005	+0.027	+0.02	+57
74739	0.408	0.420	-0.012	-0.190	-0.192	+0.002	-0.022	-0.23	+73								+0.004		
76219	0.415	0.409	+0.006	-0.184	-0.194	+0.010	-0.005	-0.14	+113								± 0.011		
76494	0.422	0.428	-0.006	-0.174	-0.189	+0.015	-0.010	-0.17	+161										

TABLE 8. BG and SG observed spectroscopically by McWilliams (1990) and Luck & Bond (1989).

HD	[Fe/H]	ΔN	$P[Fe/H]$	$\Delta[Fe/H]$	Sp.	Te	COMP	Δ
McWilliams (1990)								
3712	-0.09	+0*024	0.00	-0.09	4610*	4605*		5*
5575	-0.13	-0.004	-0.14	+0.01	4770	4710		60
9270	-0.14	-0.010	-0.17	+0.03	4910	4865		45
16161	-0.38	-0.049	-0.36	-0.02	5020	4995		25
21754	-0.12	-0.005	-0.14	+0.02	4700	4618		85
45416	-0.15	+0.001	+0.19	(-0.34)	4500	4635		-135
58367	-0.22	-0.011	-0.17	-0.05	4820	4900		-80
68752	-0.27	-0.040	-0.32	+0.05	4890	4775		115
71115	-0.34	-0.025	-0.25	-0.09	4750	4905		-155
74739	-0.14	-0.022	-0.23	+0.09	4960	4805		155
180809	-0.01	-0.011	-0.17	(+0.16)	4690	4525		165
185958	-0.03	+0.025	0.00	-0.03	4850	4785		65
199253	-0.18	-0.026	-0.25	+0.07	4540	4710		-170
				0.00 \pm 0.045				
Luck and Bond (1989)								
45829	0.00	-0.024	-0.19	(+0.19)	4500	4515		-15
47731	-0.16	-0.010	-0.17	+0.01	5000	4885		115
48329	-0.09	+0.035	+0.06	(+0.15)	4625	4595		30
62236	+0.19	+0.016	-0.04	(+0.23)	5000	4745		255
151834	+0.38	-0.050	-0.37	(+0.75)	5250	4695		555
174947	+0.18	+0.011	-0.06	(+0.24)	4850	4770		80
206859	+0.03	+0.033	+0.04	-0.07	4825	4865		-40
210745	+0.22	-0.035	-0.30	(+0.52)	4500	4400		100
223047	+0.10	+0.627	+0.02	-0.08	5000	5000		0

The apparent absence of a sensitivity to metallicity in the M_1 index for G type stars leads to a reconsideration of the F type objects discussed in Paper II. There it was found that

$$P[Fe/H](F \text{ stars}) = 2.08\Delta[M_1] + 0.03^2$$

This relation was based on ten stars with $[Fe/H]$ between -0.07 and $+0.38$ dex (Luck & Bond 1989). Two additional stars, with $[Fe/H] = -0.28$ dex (HD 9973) and -0.64 dex (HD 172365) deviate grossly from this relation. The ten defining stars show a dispersion of ± 0.09 dex. Although this calibration cannot be considered well established, it appears difficult to question its existence. Just as the m_2 and Del indices of the Geneva photometry were used above to confirm the lack of a sensitivity in M_1 to heavy element abundance in the G stars, they can also be used to confirm the presence of this sensitivity in the F stars. Table 9 contains the values of $[Fe/H]$ for ten F type SG and BG derived by Luck & Bond (1989), and the Geneva photometric indices m_2 and Del are also listed. The values of δm_2 are derived from the lower envelope of the m_2, β diagram for all of the SG and BG stars in Paper II that are also in the Geneva Photometric Catalogue (Rufener 1988);

β	m_2	β	m_2
2 ^m 78	-0 ^m 552	2 ^m 69	-0 ^m 445
2.76	-0.535	2.68	-0.425
2.74	-0.515	2.67	-0.400
2.72	-0.490	2.66	-0.365
2.71	-0.477	2.65	-0.330

Only two or three objects have $\beta < 2.650$ and these have been omitted. The lower envelope for the distribution of the stars in the β, Del plane is given by $Del = 3.20\beta - 8.130$, leading to,

²Incorrectly printed as $2.8\Delta[M_1] + 0.030$ on page 1832 of Paper II.

TABLE 9. F type SG common to Luck & Bond (1989) and the Geneva Photometry Catalogue (Rufener 1988).

HD	m_2	DEL	β	δDEL	δm_2	δm_2 (CORR)	Fe/H DEX
6474	-0*327	0*586	2*655	0*220	+0*020	0*178	+0.38
8992	-0.421	0.511	2.678	0.071	-0.001	0.134	+0.23
10494	-0.572	0.741	2.199	0.234	-0.112	0.048	-0.07
14662	-0.385	0.492	2.650	0.142	-0.055	0.091	-0.03
17971	-0.520	0.695	2.695	0.201	-0.067	0.088	+0.24
26902	-0.449	0.631	2.687	0.163	-0.010	0.139	+0.15
36673	-0.547	0.856	2.730	0.250	-0.045	0.118	-0.10
75520	-0.582	0.782	2.777	0.026	-0.034	0.146	+0.19
194093	-0.349	8.591	2.650	0.241	-0.019	0.142	+0.10
207489	-0.442	0.581	2.650	0.231	-0.112	0.046	-0.19

$$\delta Del = Del - 3.20\beta + 8.130. \quad (17)$$

The correlation of δm_2 with δDel lead to values of δm_2 corrected for gravity effects,

$$\delta m_2(\text{Corr}) = \delta m_2 + 0.150\delta Del + 0.125. \quad (18)$$

The stars of Table 9 are shown in the $[Fe/H], \delta m_2(\text{Corr})$ plane of Fig. 5 by closed circles and the straight line represents the mean relation,

$$[Fe/H] = 3.55\delta m_2(\text{Corr}) - 0.325. \quad (19)$$

Table 10 contains 50, F type BG and SG from Paper II that are also in the Geneva Photometric Catalogue. Applying Eqs. (17), (18), and (19) leads to the values of $P[Fe/H](m_2)$, whereas the values obtained from $\Delta[M_2]$ and listed in the penultimate column of Table 10 are from Paper II. The mean difference between the values of $P[Fe/H]$ is only $+0.01 \pm 0.04(\sigma)$ omitting three stars, which just as conclusively supports the sensitivity of $M_1(m_2)$ to heavy element abun-

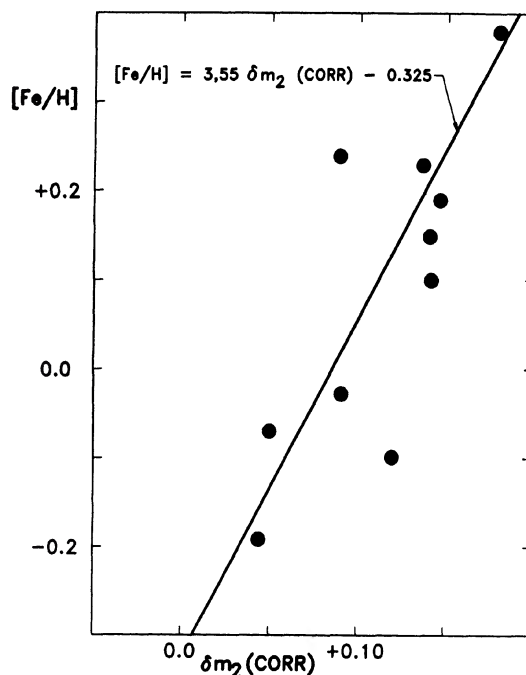


FIG. 5. The correlation of $\delta m_2(\text{corr})$, the value of δm_2 in the Geneva photometric system, corrected for gravity effects (Table 9), with spectroscopic determinations of $[Fe/H]$ for 10 F type stars (Luck & Bond 1989).

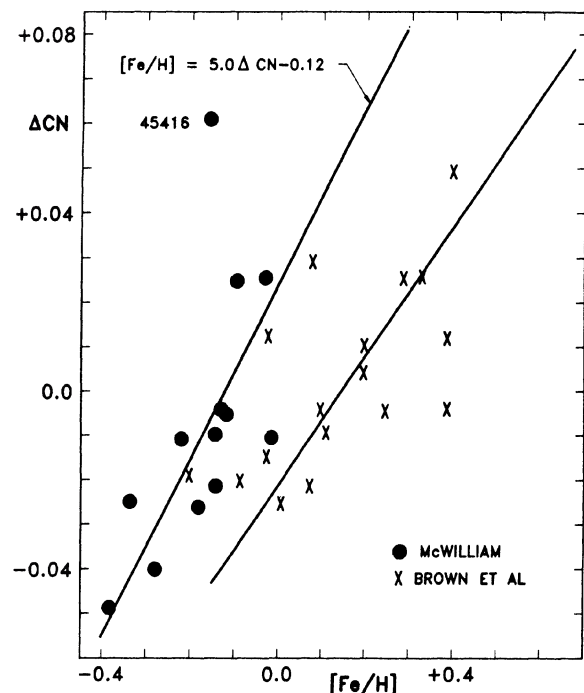


FIG. 6. The closed circles represent the correlation between ΔCN and $[\text{Fe}/\text{H}]$ for stars observed spectroscopically by McWilliam (1990). The crosses represent stars observed spectroscopically by Brown *et al.* (1989).

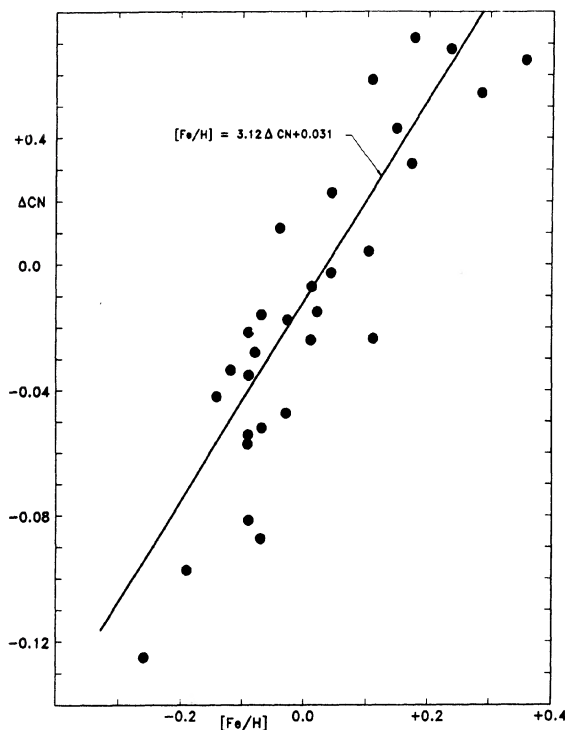


FIG. 7. The closed circles represent values of ΔCN and $[\text{Fe}/\text{H}]$ for normal (class III) giants observed spectroscopically by Brown *et al.* (1989). The straight line is the mean relation from 100 normal giants observed spectroscopically by McWilliam (1990).

dance in the F type BG and SG as m_2 support the lack of this sensitivity in the G type SG and BG.

The gravity effect in (41–42) for young disk stars of luminosity class III is corrected by Eq. (5), derived by McClure (1976). Using the same procedure, the (41–42) index for the BG and SG stars in Table 6 are normalized by

$$C_m(\text{I/II}) = (41 - 42) - 1.33[(45 - 48) - 0.851(42 - 45) - 0.506]. \quad (20)$$

The mean relation between $C_m(\text{I/II})_0$ and $(R - I)_0$ leads to

$$\Delta\text{CN} = C_m(\text{I/II})_0 - 1.90(R - I)_0 + 0.355. \quad (21)$$

The values of ΔCN are listed in Table 8 and correlated with the values of $[\text{Fe}/\text{H}]$ from McWilliam (1990) in Fig. 6 where, except for HD 45416, they are represented by

$$P[\text{Fe}/\text{H}](\Delta\text{CN}) = 5.0\Delta\text{CN} - 0.12. \quad (22)$$

In Eggen (1993, 1994) it was found that a large sample of disk stars (luminosity class III) gave values of $P[\text{Fe}/\text{H}]$ from ΔCN and $\Delta(M_1)_0$ that differed by more than 0.1 dex for only 10%, predominately CN weak in the young disk and equally divided between CN weak and CN strong in the old disk

population. HD 45416 may be a CN strong star and, possibly, HD 180808 a CN weak one. The dispersion of $[\text{Fe}/\text{H}] - P[\text{Fe}/\text{H}](\text{CN})$ is only ± 0.06 dex for 11 stars observed by McWilliam. The comparison with Luck and Bond at the bottom of Table 8 is less satisfactory.

Brown *et al.* (1989) have determined $[\text{Fe}/\text{H}]$ values for a large sample of bright stars, including the 31 young disk objects (luminosity class III) common with Eggen (1994) and represented by closed circles in the ΔCN , $[\text{Fe}/\text{H}]$ plane in Fig. 7. The straight line in the figure represents Eq. (6), derived (Eggen 1993, 1994) from over 100 disk stars in common with the spectroscopic investigation by McWilliam (1990), and equally well represented by the Brown *et al.* data, with nearly identical dispersion. It is therefore unexpected that the 16 SG and BG stars of Table 7 also discussed by Brown *et al.* and listed in Table 11, deviate so strongly from the McWilliam data in Fig. 6 where they are represented by crosses. A straight line, indicating a slightly different slope than Eq. (22), fits the Brown *et al.* data, but a systematic displacement by about +0.25 dex is equally possible. The temperature scale used by McWilliam and by Luck & Bond (1989), represented by Eq. (16), seems equally applicable to the Brown *et al.* data and apparently cannot account for this displacement. Brown *et al.* adopt a turbulent velocity of 1.7 km/s for the supergiants whereas the average

TABLE 11. Metallicities of BG and SG stars by Brown *et al.* (1989).

HD	[Fe/H] DEX	Δ CN	Sp.	Te	COMP ¹	Δ
3712	+0.33	+0.024	4470*	4605*		135
5575	+0.10	-0.004	4710	4710		0
21754	+0.25	-0.005	4710	4618		95
25877	-0.04	+0.012	4905	4910		-5
47731	-0.08	-0.020	4900	4885		5
72571	+0.20	+0.010	4780:	4795		-15
74739	+0.08	-0.022	4930	4805		125
77912	+0.20	+0.004	4910	4850		60
115004	+0.08	+0.029	4800	4690		110
150416	-0.02	-0.015	4900:	4870		30
164349	+0.39	-0.004	4450	4515		-65
174947	+0.39	+0.011	4810	4770		40
185958	+0.24	+0.025	4880	4785		105
199253	+0.01	+0.026	4580	4710		-130
206834	+0.40	+0.049	4780	4780		0
210807	-0.20	-0.019	5020	4965		55
216246	+0.11	-0.010	4910	4920		-10

¹ Eq. (16).

value for such stars in the McWilliam analysis is near 2.5 km/s.

Certainly some of the difficulty is with spectroscopic values of [Fe/H]. The overlaps amongst the three spectroscopic surveys discussed here are,

HD	McWilliam	Brown <i>et al.</i>	Luck and Bond
3712	-0.09	+0.33	
5575	-0.13	+0.10	
21754	-0.12	+0.25	
47731		-0.08	-0.16
174947		+0.39	+0.18
185958	-0.03	+0.24	
199253	-0.18	+0.01	

In summary, the values of (M_1) are essentially, luminosity dependent and do not measure the metallicity. This appears to be of some consequence for the classical Cepheids, which lie just outside the temperature range discussed here. Sandage & Tamman (1971) found that the amplitude defect, $F_B = 10^{0.4(\Delta B - B_{max})}$, is correlated with the luminosity displacement from the ridge line of the mean PL relation. Eggen (1985) found that $F_B = 1.009 - 4.545\Delta[M_1]$ for normal Cepheids, where $[M_1] = 0.3(b - y)$ and $\Delta[M_1] = [M_1] - 0.210 \log P - 0.160$, and the luminosities obtained from the PL relation using F_B (Sandage & Tamman 1971) give $\Delta M_V = 0.00 \pm 0.09(\sigma)$ mag for the normal Cepheids when F_B and $\Delta[M_1]$ are interchanged. This dependence of Cepheid luminosity on $[M_1]$ was interpreted as an abundance effect, but by analogy with the BG and SG stars discussed above, the dependence is, like that F_B , directly on the luminosity displacement from the ridge line of the PL relation. The values of Δ CN and $P[\text{Fe}/\text{H}]$ computed from Eqs. (21) and (22), respectively, for the stars in Table 6 are listed in Table 7.

This displacement of the zero-points for [Fe/H] between the SG and BG analyzed by McWilliam (1990) and Brown *et al.* (1989) needs investigation. The distribution of $P[\text{Fe}/\text{H}]$ values from Table 7 is shown in Fig. 8 where the bulk of the

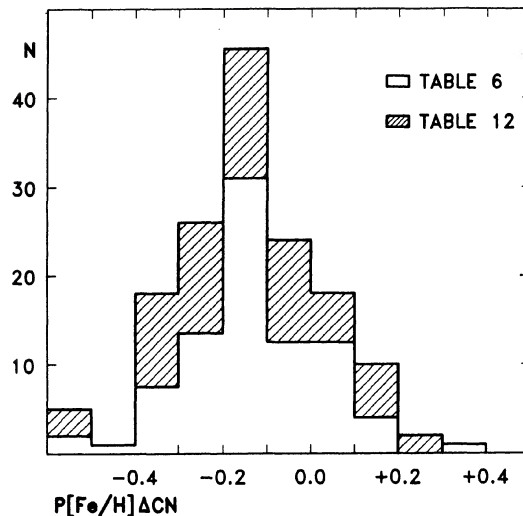


FIG. 8. The distribution of $P[\text{Fe}/\text{H}]$ values in Table 6 (clear) and Table 12 (crosshatched).

stars have $P[\text{Fe}/\text{H}](\Delta$ CN) between +0.1 and -0.3 dex with a peak at -0.1 to -0.2 dex, compared with a peak at +0.1 to +0.2 dex (Paper III, Fig. 3) for the F type stars. It may not be accidental that this displacement is the same as that in the zero-points of the [Fe/H] systems.

4. FAINT STARS

With a half dozen exceptions, the stars in Table 6 are also in the Bright Star Catalogue (Hoffleit 1982). 74 fainter stars, for which the 4 color photometry is given in Paper I, are listed in Table 12. The values of the reddening and luminosity are from Eqs. (10), (12), and (13). The mean difference in luminosity, $M_V(\text{DDO}) - M_V(4C) = -0.04 \pm 0.19(\sigma)$ mag is almost identical to that found in Table 6. Also, as noted in Table 7, the values of (M_1)₀ are almost entirely a function of luminosity [Eq. (14)]. The difference between the observed and computed values of (M_1)₀ for HD 68111, 85205, 106981, 136474, 192277, 143119, and 161388 are slightly larger than noted in Table 7, but the stars are fainter and observational errors of the indices are larger. The accidental nature of values greater than about 0.02 mag between observed and computed values of (M_1)₀ is supported by the lack of correlation between these differences and those between observed and computed values of m_2 in Table 7. For example, the difference is -0.067 mag for HD 105138 whereas in m_2 it is only 0.001 mag. Also, a difference $\Delta(M_1)_0$ of 0.054 mag for HD 223047 is contrasted with only 0.005 mag in Δm_2 .

The values of $P[\text{Fe}/\text{H}]$ derived from Δ CN in Table 12 are represented by the cross-hatched area of Fig. 8, where the distribution is very similar to that of the bright stars in Table 7. The radial distance from the Sun, positive in the direction away from the galactic center and designated X , is listed for the stars in Table 7 and 12. The median values of $P[\text{Fe}/\text{H}](\Delta$ CN), for 100 pc steps in X , are shown as closed circles

TABLE 12. Faint SG and BG of GK type.

HD	E [b-γ]	(R-I) ₀	(C _m) ₀ (1-11)	δ(45-48) ₀	A(u-b) ₀	V ₀	M _v D00	4C	(M _v) ₀ OBS	COMP	ACN	P [Fe/N]	ACN	COMP	Sp.T.	OBS	s ¹	X	Note
44812	0 ^m .034	0 ^m .307	0 ^m .246	0 ^m .031	0 ^m .145	6 ^m .94	-1 ^m .49	-1 ^m .58	0 ^m .472	0 ^m .471	0.000	-0.12	0.000		G6/8 II		1	+469	
49775	0.044	0.312	0.215	0.008	0.065	6.95	-1.10	-1.02	0.407	0.425	-0.043	-0.33	-0.043		G6/8 II-III		2	+86	
50372	0.018	0.339	0.343	0.028	0.138	7.02	-1.88	-1.86	0.539	0.529	+0.033	+0.05	+0.033		K0 II		2	+515	
58134	0.071	0.293	0.260	0.039	0.183	7.34	-1.45	-1.72	0.470	0.465	+0.008	-0.08	+0.008		G6/8 II	G5 Ib	3	+275	X
59367	0.078	0.310	0.245	0.003	0.068	8.25	-0.97	-1.02	0.413	0.422	+0.009	-0.16	+0.009		G6/8 II-III	G8 II	4	+544	
62236	0.045	0.327	0.302	0.040	0.157	7.86	-1.95	-1.88	0.518	0.518	+0.016	-0.04	+0.016		K0 II	G5 Ib	4	+544	X
64858	0.065	0.284	0.160	0.032	0.160	8.28	-1.19	-1.44	0.395	0.430	+0.045	-0.34	+0.045		G5 Ib-III	G3 Ib	5	+374	X
65297	0.150	0.307	0.278	0.039	0.138	6.80	-1.65	-1.52	0.485	0.464	+0.030	+0.03	+0.030		G6/8 II	G3 Ib	6	+23	X
68111	0.123	0.291	0.167	0.045	0.215	7.65	-1.55	-1.94	0.436	(0.483)	+0.050	-0.37	+0.050		G5 Ib	G3 Ib	5	+212	X
70385	0.099	0.312	0.284	0.048	0.223	7.36	-1.90	-2.22	0.483	0.490	+0.026	+0.01	+0.026		G6/8 Ib-III	G5 Ib/III	6	-61	
71181	0.091	0.318	0.244	0.029	0.081	7.25	-1.60	-1.20	0.449	0.448	-0.025	-0.25	-0.025		G6/8 II	G6 Ib/III	2	+69	
72125	0.122	0.346	0.336	-0.001	0.048	7.81	-1.39	-1.25	0.460	0.478	-0.004	-0.14	-0.004		K0 II-III	K1 II	2	+80	
80128	0.057	0.338	0.295	0.066	0.210	7.08	-2.62	-2.40	0.567	0.576	-0.012	-0.18	-0.012		K0 Ib	G6 Ib	6	-212	
81949	0.074	0.281	0.197	0.037	0.138	6.56	-1.24	-1.25	0.416	0.410	-0.002	-0.13	-0.002		G5 II	G3/5 Ib	6	-36	
82122	0.071	0.279	0.161	-0.004	0.027	9.04	-0.40	-0.38	0.334	0.330	-0.033	-0.29	-0.033		G5 II-III	G5/6 II	2	-35	
83111	0.034	0.351	0.355	-0.006	0.050	6.87	-1.36	-1.32	0.477	0.494	+0.023	0.00	+0.023		K1 II-III	K0 II	6	-83	
83657	0.065	0.338	0.305	0.019	0.090	7.58	-1.68	-1.48	0.513	0.495	-0.004	-0.14	-0.004		K0 Ib-III	K1 II	6	-98	
83898	0.112	0.314	0.269	0.043	0.172	8.41	-1.83	-1.85	0.498	0.500	+0.007	-0.08	+0.007		G6/8 Ib/III	G6 Ib/III	6	-203	
84341	0.108	0.387	0.396	0.021	0.145	8.24	-2.35	-2.42	0.605	0.630	-0.004	-0.14	-0.004		K1 Ib-III	K1 II	6	-278	
85205	0.030	0.300	0.297	0.000	0.035	8.25	-0.77	-0.67	0.430	(0.380)	+0.062	+0.19	+0.062		G6/8 II	G6 II	5	+36	
85530	0.076	0.305	0.249	0.025	0.097	7.64	-1.34	-1.19	0.448	0.432	+0.005	-0.10	+0.005		G6/8 II	G8 II	6	-121	
89373	0.040	0.419	0.452	0.010	0.131	7.91	-2.43	-2.64	0.658	0.671	-0.009	-0.16	-0.009		K1 Ib-III	K1 Ib/III	6	-295	
93807	0.070	0.351	0.379	0.051	0.225	6.82	-2.50	-2.82	0.560	0.590	+0.036	-0.30	+0.036		K0 Ib	G3 Ib	6	-260	
95393	0.175	0.319	0.235	0.087	0.292	6.57	-2.78	-2.82	0.635	0.620	+0.047	+0.12	+0.047		G6/8 II	G5 Ib/III	6	-287	
97189	0.128	0.303	0.217	0.039	0.132	7.77	-1.59	-1.43	0.443	0.450	-0.024	-0.24	-0.024		G6/8 II	G5 Ib/III	6	-287	
98386	(0.175)	0.294	--	--	0.161	6.65	--	-1.56	0.472	0.453	--	--	--		G6/8 II	G6 II	6	-168	X
98782	0.045	0.317	0.237	0.003	0.010	8.05	-0.97	-0.65	0.406	0.398	-0.030	-0.27	-0.030		G6/8 II-III	G6 II	6	-216	
99154	0.009	0.270	0.160	0.013	0.063	8.02	-0.61	-0.56	0.341	0.336	-0.018	-0.21	-0.018		G5 II-III	G5 II	6	-189	
99313	0.132	0.272	0.136	0.045	0.193	7.85	-1.28	-1.57	0.395	0.425	-0.046	-0.35	-0.046		G5 II	G3 II	6	-279	
99576	0.200	0.276	--	--	0.296	8.20	--	-2.40	0.520	0.506	--	--	--		G5 Ib	G3/5 Ib	6	-515	
100137	0.050	0.333	0.305	0.006	0.048	7.75	-1.04	-1.11	0.455	0.455	+0.007	-0.08	+0.007		K0 II-III	G8 II	6	-229	
103134	(0.054)	0.306	--	--	0.129	9.32	--	-1.44	0.466	0.492	--	--	--		G6/8 II	G8 Ib/III	5	-423	X
103225	0.180	0.290	0.213	0.050	0.158	7.10	-1.63	-1.50	0.453	0.442	-0.003	-0.14	-0.003		G5 II	G3 Ib	6	-244	
104096	0.154	0.326	0.337	0.003	0.071	8.68	-1.19	-1.21	0.440	0.455	+0.053	+0.14	+0.053		G6/8 II	G6 Ib/III	6	-439	
104215	0.173	0.324	0.315	0.080	0.273	7.06	-2.71	-2.73	0.620	0.592	+0.034	+0.05	+0.034		G6/8 Ib	G6 Ib	6	-410	
104857	0.115	0.326	0.297	0.036	0.143	7.53	-1.85	-1.76	0.520	0.506	+0.014	-0.05	+0.014		K0 II	K0 IIb/III	6	-343	
106981	0.157	0.294	0.180	0.063	0.244	6.97	-1.95	-2.19	0.458	(0.508)	-0.044	-0.34	-0.044		G6/8 Ib	G3 Ib	6	-305	
112782	0.188	0.318	0.310	0.060	0.179	7.48	-2.22	-1.95	0.536	0.516	0.041	+0.08	0.041		G6/8 Ib-III	G6 Ib/III	6	-451	

TABLE 12. (continued)

HD	E(lb-γ)	(R-1) ₀	(C _m) ₀	(I-11)	δ(45-48) ₀	A(lu-b)	V ₀	DDO	M _V	4C	OBS	(M ₁) ₀	COMP	ACN	P[Fe/H]	ACN	COMP	Sp.T.	OBS	s ¹	X	Note
113190	0.245	0.302	0.200	0.039	0.137	7.80	-1.58	-1.46	0.421	0.450	-0.039	-0.31	G6/8 II	G6/8 II	6	-412						
114756	0.210	0.313	0.280	0.071	0.204	6.44	-2.37	-2.09	0.546	0.525	+0.020	-0.02	G6/8 Ib-II	G6 II	6	-313						
120112	0.080	0.384	-	-	0.026	7.21	-	-1.48	0.548	0.547	-	-	K2 II-IIII	K2 II-IIII	6	-184						
120537	0.143	0.305	0.228	0.052	0.177	8.17	-1.88	-1.80	0.481	0.486	-0.016	-0.20	G6/8 Ib-II	G4 Ib-II	6	-620						
125809	0.090	0.320	0.278	0.074	0.217	6.03	-2.53	-2.26	0.536	0.544	+0.005	-0.10	G6/8 Ib	G6 Ib	5	-356						
129330	0.125	0.282	-	-	0.137	6.82	-	-1.25	0.410	0.411	-	-	G5 Ib-II	G5 Ib-II	6	-275						
132223	0.090	0.307	-	-	-0.002	7.65	-	-0.46	0.343	0.368	-	-	G6/8 II-IIII	G6 II	6	-320						
134704	0.052	0.275	0.143	0.007	0.005	7.69	-0.56	-0.56	0.325	0.340	-0.044	-0.34	G5 II-IIII	G5 II	5	-370						
136456	0.102	0.312	0.246	0.006	0.047	9.56	-1.06	-0.88	0.409	0.412	-0.012	-0.18	G6/8 II-IIII	G5 Ib-II	6	-925						
136474	0.110	0.307	0.228	0.056	0.217	7.43	-2.00	-2.12	0.469	0.517	-0.020	-0.22	G6/8 Ib-II	G3 Ib-II	6	-573						
136505	0.072	0.309	0.236	0.044	0.160	6.41	-1.78	-1.71	0.471	0.482	-0.016	-0.20	G6/8 II	G5 Ib-II	2	-350						
136537	0.112	0.305	0.202	0.050	0.207	6.32	-1.84	-2.02	0.490	0.506	-0.042	-0.33	G6/8 Ib	G8 Ib	6	-354						
142227	0.118	0.282	0.223	-0.001	0.080	7.11	-0.50	-0.82	0.326	0.373	+0.022	-0.01	G6/8 II-IIII	K0 II+G	2	-322						
142584	0.141	0.311	0.250	0.042	0.150	6.68	-1.76	-1.66	0.476	0.480	-0.006	-0.15	G6/8 II	G6Ib-II	6	-396						
142811	0.161	0.314	0.286	0.018	0.094	8.43	-1.33	-1.26	0.431	0.447	+0.024	0.00	G6/8 II	G6 II	2	-766						
143119	0.235	0.281	0.123	0.052	0.192	6.45	-1.54	-1.66	0.360	0.446	-0.076	(-0.50)	G5 Ib-II	G0 Ib-II	2	-367						
144338	0.125	0.396	0.425	0.034	0.113	6.86	-2.69	-2.27	0.636	0.630	+0.008	-0.08	K1 II	G8/K0 II	2	-666						
146148	0.126	0.296	0.233	0.040	0.159	6.96	-1.51	-1.56	0.460	0.456	+0.006	-0.09	G6/8 II	G6 Ib-II	6	-419						
146525	0.100	0.284	0.234	0.042	0.117	7.87	-1.39	-1.12	0.439	0.405	+0.029	+0.03	G5 II	G6 II	2	-585						
150675	0.075	0.345	0.315	0.013	0.080	6.80	-1.66	-1.48	0.482	0.502	-0.006	-0.15	K0 II	K1 II	2	-435						
151834	0.435	0.324	0.230	0.143	0.431	6.38	-3.97	-3.93	0.616	0.670	-0.050	-0.37	G6/8 Ia	G3 Iab	2	-1110						
151856	0.027	0.424	0.604	-0.005	0.057	7.77	-2.18	-2.14	0.616	0.650	(+0.133)	(+0.55)	K1 II-IIII	K2 III	5	-947						
153639	0.123	0.338	0.339	0.057	0.203	6.52	-2.49	-2.34	0.572	0.572	+0.032	+0.04	K0 Ib	G5 Ib	7	-577						
154813	0.110	0.348	0.305	0.039	0.123	6.32	-2.22	-1.84	0.528	0.538	-0.021	-0.23	K0 II	G5/6 Ib	5	-410						
157549	0.270	0.307	0.304	0.085	0.258	7.26	-2.57	-2.43	0.570	0.545	+0.056	+0.16	G6/8 Ib	G6/8 II	5	-894						
160706	0.350	0.329	0.353	0.121	0.389	6.85	-3.58	-3.65	0.674	0.676	+0.063	+0.19	K0 Iab	G8 Iab	7	-1242						
161388	0.446	0.271	0.084	0.115	0.370	6.36	-2.66	-2.90	0.388	0.388	(-0.545)	(-0.60)	G5 Iab	G1 Iab	5	-705						
162585	0.147	0.361	0.293	0.060	0.185	6.17	-2.82	-2.45	0.550	0.607	+0.050	+0.13	K0 Ib-II	G6 Ib-II	5	-577						
164774	0.157	0.354	0.350	0.091	0.306	6.36	-3.35	-3.29	0.674	0.674	+0.012	-0.06	K0 Ib	G5 Ib	5	-852						
167506	0.130	0.279	0.128	0.096	0.284	6.13	-2.40	-2.34	0.499	0.504	-0.067	-0.45	G5 Ib	G5 Ib	8	-492						
169660	0.135	0.317	0.248	0.076	0.275	6.69	-2.53	-2.67	0.574	0.577	-0.019	-0.22	G6/8 Ib	G8 Ib	7	-708						
170457	0.235	0.314	0.308	0.074	0.236	5.97	-2.45	-2.34	0.562	0.547	+0.046	+0.11	G6/8 Ib	G5 Ib	7	-463						
173388	0.501	0.288	0.215	0.145	0.405	4.69	-3.50	-3.35	0.576	0.600	+0.003	-0.10	G6/8 Iab	G5 Ib	4	-390						
173568	0.225	0.337	0.287	0.090	0.270	7.62	-3.09	-2.84	0.600	0.600	-0.018	-0.21	K0 Ib	G5 Ib	7	-1201						
179440	0.250	0.304	0.262	0.052	0.138	7.42	-1.86	-1.50	0.454	0.454	+0.019	-0.02	G6/8 Ib-II	..	7	-442						
189337	0.020	0.306	0.217	0.034	0.144	6.42	-1.53	-1.55	0.437	0.465	-0.029	-0.27	G6/8 II	G7 Ib-II	3	-243						

TABLE 12. (continued)

Notes to TABLE 12.

1			
1-	Sources of spectral types (S).		
2-	Fehrenback and Reibrot 1961.		
3-	Houk 1978.		
4-	Keenan and McNeil 1989.		
5-	Houk and Smith-Moore 1988 Houk 1982.		
		6-	Houk and Cowley 1975.
		7-	McConnell and Bidelman 1976.
		8-	Hoffleit 1984.
		9-	Moore and Paddock 1950.
		10-	Drilling 1968.
HD 58134			
HD 64858			
HD 68111			
HD 98386			
HD 103225			
HD 120112			
HD 136505			
HD 142227			
HD 142584			
HD 143119			
HD 150675			
HD 153639			
HD 160706			
HD 169660			
HD 170457			
	G5 II (Houk 1982).		
	G4 Iab/Ib (Keenan and McNeil 1989).		
	"Badly overlapped and possibly composite".		
	A neighboring star, HD 98410, B2.51B, with $(V, b-y, M_1, C_1, \beta) = (8.84, 0.674, -0.002, 0.057, 2.539)$ mag is an optical companion with $H\beta$ emission.		
	A neighboring star, HD 103336, B3Ib, which has $(V, b-y, M_1, C_1, \beta) = (7.49, 0.174, -0.005, 0.217, 2.576)$ mag, is an optical companion. This companion was mislabeled HD 103335 in Paper I.		
	HD 112013, 12.5 arcsec distant, has $(V, b-y, M_1, C_1, \beta) = (8.03, 0.207, -0.031, 0.119, 2.587)$ mag, B2(III), and is an optical companion.		
	G5 Ib (McConnell and Bidelman 1970).		
	G8 II (Drilling 1973).		
	"Overlapped and probably composite".		
	G3 Ib (McConnell and Bidelman 1976).		
	K1 Ib (Hoffleit 1984).		
	G8 III (Houk 1978).		
	G3 Ib/II (Houk 1982).		
	G3 Iab/Ib + (A), "possibly composite" (Houk 1982).		
	G8 Ib/II (Houk and Smith-Moore 1988).		

Notes to TABLE 12.

TABLE 14. Stars classified as SG or BG but with photometric indices of normal giants.

HD	E(b-y)	(R-I) ₀	(C _m) ₀	A(45-48) ₀	[C ₁]	V ₀	D00	M _V	4C	A(M ₁) ₀	ACN	P[Fe/H]	D00	COMP	Sp.T.	OBS	s ¹	Note
15589	0 ^m .018	0 ^m .370	0 ^m .224	0 ^m .044	0 ^m .003	8 ^m .90	+0.21	(-1 ^m .20)	-0 ^m .023	-0 ^m .056	+0.03	-0.14	K0 III	G8 III			5	A
36079	0.010	0.294	0.080	0.106	0.294	2.79	-0.41	(+1.00)	-0.128	-0.116	+0.29	-0.33	G5 III	G5 III			3	X
47209	0.008	0.299	0.254	0.068	0.260	7.03	+0.56	+0.47	+0.046	+0.053	+0.25	+0.19	G8 III	G8 III			5	
49367	0.012	0.380	0.288	0.065	0.218	7.23	-0.54	-0.22	+0.024	-0.004	+0.18	+0.02	K1 III	K1 III			9	
55751	0.033	0.369	0.254	0.087	0.209	5.73	-0.73	-0.20	+0.024	-0.025	+0.18	-0.05	K0 III	K2 III			8	
61561	0.035	0.315	0.217	0.069	0.232	9.19	+0.45	+0.23	-0.032	-0.002	0.00	+0.02	G8 III	K0 III			6	
61714	0.036	0.295	0.144	0.072	0.377	7.65	+0.90	+1.05	-0.042	-0.050	-0.03	-0.12	G6/8 III	G6/8 III			2	
61713	0.036	0.295	0.144	0.072	0.377	7.65	+0.90	+1.05	-0.042	-0.050	-0.03	-0.12	G6/8 III	G6/8 III			2	
66675	0.033	0.291	0.222	0.056	0.090	9.13	+1.00	(-0.31)	(+0.037)	+0.004	(+0.22)	+0.04	A0 V	A0 V			2	
75866	0.056	0.322	0.223	0.058	0.310	8.03	+0.54	+0.57	+0.027	-0.004	+0.18	+0.02	G8 III	G8 III			5	X
84610	(0.010)	0.294	0.301	0.064	0.057	7.81	+0.56	(-0.50)	+0.100	-0.004	+0.18	+0.02	G8 III	G8 III			2	
88495	(0.014)	0.294	0.273	0.014	0.143	8.44	+1.65	(-0.08)	+0.042	+0.105	+0.42	+0.36	G6/8 III-III	G8 III			5	A
102350	0.015	0.286	0.161	0.089	0.355	4.04	+0.60	+0.95	-0.036	-0.026	+0.23	+0.27	G8 III	G8 III			5	A
110483	(0.025)	0.321	0.304	0.084	-0.081	8.39	-0.20	--	--	-0.078	-0.01	-0.05	G5 III	G5 III			6	X
117341	(0.012)	0.330	0.296	0.066	0.017	8.39	+0.07	(-0.90)	+0.034	+0.060	+0.21	+0.22	G8 III	G8 Ib/III			2	A
124198	0.061	0.305	0.242	0.072	0.234	8.27	+0.44	+0.30	+0.025	+0.034	+0.18	+0.14	G8 III	G8 Ib/III			6	A
145302	0.100	0.293	0.172	0.081	0.301	9.07	+0.63	+0.40	+0.001	-0.023	+0.10	-0.04	G5 III	G4 III			6	X
145336	0.131	0.278	0.245	0.068	0.276	8.64	+0.86	+0.66	+0.090	+0.067	+0.38	+0.24	G5 III	G5 III			10	X
184591	0.040	0.275	0.216	0.057	0.392	7.17	+1.21	+1.24	-0.032	+0.041	0.00	+0.16	G5 III	G8 III			5	
184624	0.100	0.353	0.185	0.038	0.339	9.39	+0.67	+0.51	-0.032	+0.041	0.00	+0.16	G5 III	G2 I			5	
186962	0.028	0.319	0.240	0.069	0.307	7.49	+0.22	+0.51	-0.087	-0.076	-0.18	-0.21	K0 III	K0 III			5	
187348	(0.080)	0.272	0.190	0.044	0.184	7.13	+1.59	(+0.25)	(+0.082)	+0.019	+0.10	+0.08	G8 III	G8 III			9	
198590	0.011	0.272	0.291	0.063	0.202	6.85	+0.90	+0.34	+0.090	+0.120	+0.36	+0.09	(G5 III)	G8 III			5	X
201409	0.010	0.292	0.204	0.073	0.298	7.24	+0.70	+0.70	+0.014	+0.010	+0.14	+0.06	G5 III	G8 III			5	

Notes to TABLE 14.

1 S.
 Note A
 HD 36079 Possibly a CH+ (BaII) star on the basis of [C₁].
 HD 61713/4 Possibly a CH- (weak G band star). (U, V, W) = (-18.8, +1.8, +1.9) km/sec. [Fe/H] = 0.41 dex. McWilliam (1990).
 HD 66675 Optical Double.
 HD 102350 Probably a BaII star. Called HD 66604 in Paper I.
 HD 12418 (U, V, W) = (+5.7, +1.0, -4.6) km/sec.
 HD 145302 *4290 and MY weak for luminosity indicated by 4077 and CN break*. (Houk and Cowley 1975).
 HD 145302 G8 (III). (Houk and Cowley 1975).
 HD 187368 Reddening uncertain. Possibly a peculiar or composite spectrum.

TABLE 15. Problem stars.

HD	E(b-y)	(R-I) ₀	(C _m) ₀	δ(45-48) ₀	Δ(u-b) ₀	V ₀	DDO	M _y	4C	μ _a /μ _s	0 ^m 001	P	U	V	W	COMP	Sp. T.	Obs	Note
									km/sec	km/sec		km/sec	km/sec	km/sec					
6446	0 ^m 143	0 ^m 410	0 ^m 183	0 ^m 033	0 ^m 167	6 ^m 63	-2 ^m 80	-2 ^m 82	42/-44	+16.6	+40.3	-209.5	+91.9		K1 Ib-II	K2 II		X	
13640	0.029	0.397	0.471	-0.003	0.245	8.77	(-1.96)	-3.25	--	--	--	--	--	--	K1 Ib	K1 II		X	
28085	0.133	0.350	0.237	0.009	0.096	6.93	-1.65	-1.65	-1/-6	-11.6	-15.1	-9.4	-7.1		(K0 III)	--		X	
49396	0.037	0.285	0.197	0.049	0.284	6.40	-1.54	-2.40	--	+17.0	--	--	--		G5 Ib	G2 Ib		X	
53208	0.031	0.381	0.390	0.050	0.075	5.49	(-2.87)	-1.82	-10/5	+40.3	+39.2	-15.7	-8.9		K1 II	G3 Ib		X	
63700	0.084	0.292	0.215	0.096	0.447	3.06	(-2.58)	(-3.71)	-3/-2	+2.7	+1.2	-2.2	-2.2		(G5 1ab)	G3 Ib		A	
74006	0.030	0.287	0.185	0.005	0.068	3.85	-0.69	-0.78	10/-18	-14.2	-11.0	+11.8	-2.2		G5 II-III	G5 I/II		X	
84533	0.198	0.346	0.295	0.082	0.157	7.91	-3.05	-2.08	--	--	--	--	--		K0 Ib-II	G5/6 Ib		X	
85622	0.072	0.320	0.281	0.058	0.135	4.29	-2.21	(-1.64)	-18/7	+10.8	+16.6	-12.3	-4.5		(G6/8 II)	G5 Ib		X	
87109	0.073	0.344	0.335	0.048	0.130	7.35	-2.35	-1.85	--	--	--	--	--		K0 II	G8 Ib/II		A	
88756	0.090	0.365	0.382	0.046	0.139	7.48	-2.60	(-2.14)	--	--	--	--	--		K0 II	K0 Ib/II		A	
89175	(0.010)	0.334	0.384	(-0.019)	--	7.68	--	--	--	--	--	--	--		--	G8 Ib/II		A	
111315	0.038	0.335	0.368	0.022	0.025	5.40	-1.70	(-0.95)	--	-5.0	--	--	--		(K0 II-III)	G8 Ib/II		A	
135551	(0.050)	0.316	0.415	0.017	0.086	7.96	-1.33	-1.22	--	--	--	--	--		G6/8 II-III	G6/8 II		A	
136635	(0.080)	0.300	0.359	0.007	--	8.32	-0.91	--	--	--	--	--	--		G6/8 II-III	G6/8 II		A	
143084	0.228	0.344	0.312	0.089	0.172	5.54	(-3.17)	-2.17	-9/-20	-26.2	+34.4	-21.5	-19.0		K0 Ib-II	K1 II/III		X	
147225	0.178	0.273	0.156	0.044	0.177	5.16	-1.27	-1.49	-7/-16	-10.6	+14.9	-9.9	-7.0		G5 II	G3 II		X	
148218	(0.150)	0.354	0.323	0.069	0.219	5.46	-2.91	-2.63	-3/0	+5.1	-2.5	-3.5	+3.9		K0 Ib	G8 Ib		X	
153573	(0.2)	0.288	0.117	0.116	0.038	7.40	(-2.92)	(-0.56)	--	--	--	--	--		(G5 II-III)	G2 Ib		X	
169420	0.256	0.324	0.239	0.026	0.073	3.74	-1.63	(-1.20)	6/21	-11.8	--	--	--		K2 II	K2 II		X	

Notes to TABLE 15.

Note A
 HD 6446
 HD 13640
 HD 28085
 HD 49396
 HD 53208
 HD 74006

The small value of [C₁] indicates a CH*(Ball) star or composite system with an early type companion. K2IIpCMIV/V "possibly composite". (Houk and Cowley 1975).
 The 4 color observations are consistent, giving Δ(M₁)₀ = -0.007 mag. The DDO results indicate strong CH, with ACN = 0.057 mag, leading to Fe/H = +0.16 dex. Possibly a CH* star.
 Although the luminosity determinations are identical, the value of (u-b) = 1.474 indicates a normal giant. ACN gives P[Fe/H] = -0.58 dex.
 The value of (M₁)₀ = 0.455 mag is inconsistent with the computed value of 0.516 mag. The spectral type is called G8 Iab by Keenan and McNeil (1989).
 The value of (M₁)₀ = 0.630 mag is inconsistent with the computed value of 0.575 mag. Probably a peculiar star.
 Beta Pyx. The only problem with this object is that the v-motion is unique for a young disk star. The problem may be with the proper motion, which needs strengthening. The radial velocity is possibly variable.

TABLE 15. (continued)

<p>HD 84533 HD 85622 HD 135551</p>	<p>HD 143084 HD 147225 HD 148218 HD 153573 HD 169420</p>	<p>*Possibly a Ball star (Houk and Cowley 1975) and this is supported by the indices. Sp.B., P = 329d. The companion may be an earlier type star and influencing the [u-b] index. Very strong CN. The spectral type (Hok 1972) is G8 IICM1b. The galactic latitude is only +4.0°, and Eq.(10) obviously gives the incorrect reddening of 0.012 mag. The value of [C₁] is only 0.015 mag and the star may be a CH+(Ball) object. The observed and computed values of (M₁)₀ are, respectively, 0.558 and 0.447 mag, which is inconsistent with normal BG and SG. CN = 0.150 mag leading to P[Fe/H] = +0.63 dex. McConnell and Bidelman (1976) call the type G5 Ib. The luminosity from DDO photometry would place the star well outside the young disk domain of the (U, V) plane. The observed value of (M₁)₀ = 0.358 mag is inconsistent with the computed value of 0.420 mag. The large value of C₁ = 0.542 mag indicate a CH- (weak G-band) star. The only problem is that the reddening from Eq.(10) is substantially smaller than the value adopted here from neighboring, early type stars. The spectral type is by McConnell and Bidelman (1976). Houk (1982) call it G8 III+G, "probably composite". A 7.6 mag star 1.8 arcsec distant is probably of early type and influencing the indices. The spectral type is from Hoffleit (1982); Houk and Smith-Moore (1988) find K1 III.</p>
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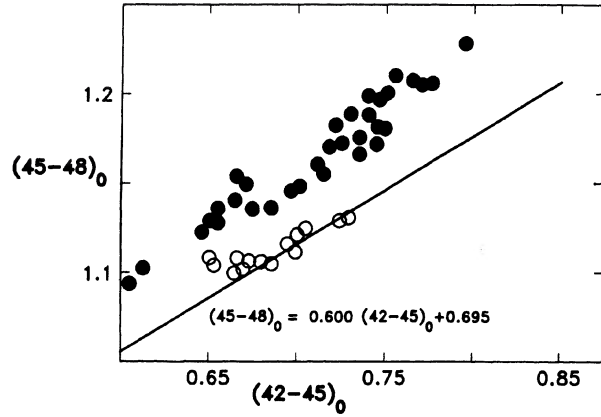


FIG. 10. The G0/3 I stars (closed circles) and G0/3 II stars (open circles) in the 45-48, 42-45 plane. The straight line is the extrapolation of the upper envelope for the normal (class III) giants of type GK.

type stars [Eq. (11)]. The stars in the figure are clearly separated into what are spectroscopically defined as luminosity-class II and I objects, and those of class I are represented by closed circles. The class I stars are listed in Table 16 where the values of $E(b-y)$ are obtained from Eq. (10), $(C_m)_0$ from Eq. (20), and $\delta(45-48)_0$ from Eq. (11). The quantity $[u-b]$, Eq. (13), has been redefined for the G0/3 stars

$$\delta[u-b] - [u-b] - 1.200. \tag{23}$$

The luminosities are derived from

$$M_V(\text{DDO}) = 2.5(R-I)_0 - 20.0 \delta(45-48)_0 - 3.40, \tag{24}$$

$$M_V(4C) = 2.5(R-I)_0 - 5.9 \delta[u-b] - 2.75. \tag{25}$$

The following checks on the luminosity calibrations are available.

HD 204867/209750 (α and β Aqr): These stars are separated by some 10° but have nearly identical apparent motions. This motion is shared with the early type star HD 209409 (κ Aqr), a variable shell star, and at least three fainter objects; HD 208349(A2), -1°4247(F) and HD 209905(B9) (see Eggen 1985, Tables XXI and XXII). The mean modulus of these four stars is the same as that of HD 204867 and 209750 in Table 16.

Long Period Cepheids: The LPC fall in the temperature domain is discussed here. The five variables for which DDO photometry is available and discussed in Sec. 1 are

LPC	$(R-I)_0$	$\delta(45-48)_0$	$\delta[u-b]$	DDO	M_V 4C	PL	$\log P$
RS Pup	0 ^m 267	0 ^m 139	0 ^m 894	-5 ^m 51	-5 ^m 25	-5 ^m 71	1.617
T Mon	0.251	0.116	0.860	-5.09	-5.16	-5.16	1.432
VY Car	0.239	0.115	0.814	-5.10	-4.98	-4.72	1.277
SV Mon	0.210	0.099	0.847	-4.86	-4.82	-4.71	1.183
V340 Nor	0.224	0.069	0.792	-4.22	-4.56	-4.35	1.054

The luminosities labeled “PL” are from the period–luminosity relation (Eggen 1985). V340 Nor is in the direction of NGC 6067 and the background Norma OB I association (Eggen 1988) which have, respectively, moduli of 10.5 and 11.6 mag, or $M_V = -3.1$ mag for the Cepheid if it is a member of the cluster and -4.2 mag if a member of the association. VY Car is a member of a cluster for which the early type stars give a modulus of 11.55 mag (Eggen 1980).

The stars of Table 16 are represented with closed circles in the color–luminosity array of Fig. 3. The few objects with reliable apparent motions are also represented by closed circles in Fig. 4. The “computed” spectral type of G0/3 Ib for all these stars agrees well with the available spectroscopic results noted in Table 16.

Like the later type stars discussed in Sec. 3, the G0/3 stars in Table 16 have values of $(M_1)_0$ that are sensitive only to the luminosity. This can be demonstrated with the objects that have Geneva Photometry (Rufener 1988) and listed in Table 17,

$$m_2 = [B1 - B2] - 0.457[B2 - VI],$$

$$\text{Del} = [U - B2] - 0.832[B2 - G],$$

$$\Delta m_2 = m_2 - 1.95(R - I)_0 + 0.695,$$

$$\Delta \text{Del} = \text{Del} - 1.60(R - I)_0 + 0.695,$$

$$\Delta m_2 = +0.002 + 0.620 \Delta \text{Del},$$

so

$$m_2 = 0.958(R - I)_0 + 0.620 \text{Del} - 0.722. \quad (26)$$

Removing the luminosity effect from m_2 with Eq. (26), leaves a mean value of $O - C = +0.001 \pm 0.009(\sigma)$ mag and either the values of m_2 (like M_1) are indicating that all the stars have essentially the heavy element abundance, or the indices are sensitive to the luminosity (gravity) alone.

The values of ΔCN , which are correlated with $[\text{Fe}/\text{H}]$ for the later type stars discussed in Sec. 3, are listed in Table 16.

$$\Delta \text{CN}(G0/3 \text{ I}) = (C_m)_0 - 0.130(R - I)_0 + 0.220. \quad (27)$$

The values of ΔCN are all very small and except for about four stars, indicate a metallicity spread of less than $P[\text{Fe}/\text{H}] = 0.1$ dex. There are not enough reliable determinations of $[\text{Fe}/\text{H}]$ to attempt a correlation;

HD	CN	$[\text{Fe}/\text{H}]$	Source
4362	-0.028	-0.12	Luck & Bond (1989)
16901	+0.007	-0.08	Luck and Bond
26630	-0.002	+0.15	Luck and Bond
26630	-0.002	-0.32	McWilliam (1990)
31910	+0.006	-0.25	McWilliam
57146	+0.023	+0.03	McWilliam
159181	-0.019	+0.14	Luck and Bond
209750	+0.008	+0.10	Luck and Bond

It appears possible that, like M_1 , the values of C_m for the G0/3 I stars have little or no sensitivity to heavy element abundance.

The stars shown as clear circles in Fig. 10 are equated to luminosity class II and are listed in Table 18. Very little is known about the luminosity of these objects. From internal evidence, the slope of $\Delta M_V / \delta(45-48)_0$ increases for stars with $\delta(45-48)_0 < 0.04$ mag whereas the values $\Delta M_V / \delta[u-b]$ appear to be continuous over the whole temperature range ($R - I = 0.15$ to 0.27 mag). Consequently, Eq. (25) has been used for $M_V(4C)$ in Table 18 and, for the DDO indices,

$$M_V(\text{DDO}) = 2.5(R - I)_0 - 37.0 \delta(45 - 48)_0 - 2.70. \quad (28)$$

The luminosities of stars in Table 18 that have accurate apparent motions are;

	$\mu_\alpha \mu_\delta$	ρ	V			Modulus
	0 ^m 001	km/s	U	km/s	W	
24395	-9/1	+31.4	+26.3	-21.5	+1.9	7 ^m 25
84441	-46/11	+20.2	+20.2	-9.4	-13.4	7.25
119605	13/-4	-20.0	-20.1	+6.0	-9.5	7.85
222754	14/-1	+17.8	+17.8	-9.0	-10.9	7.65

These, together with the space motions in Table 16, are represented with filled circles in Fig. 4.

The region of the G0/3 stars ($R - I = 0.15$ to 0.27 mag, $T_e \sim 5000^\circ$ to 5600°) extending from the class II giants ($M_V \sim -2.5$ mag, $t \sim 2 \times 10^8$ yr) to the class IV subgiants ($M_V \sim +3.0$ mag, $t \sim 5 \times 10^9$ yr) is one of the most sparsely populated in the color–luminosity array. Two giants, 31 Com(G0 III, $R - I = 0.23$ mag) in Coma Berenices and HD 72779 (G0 III, $R - I = 0.24$ mag) in Praesepe, both with $M_V \sim +0.4$ mag ($t \sim 10^9$ yr), are rare exceptions. This sparseness is the result of both evolutionary rates and the timing of star formation bursts. As noted in Sec. 2, there apparently was little or no star formation in the solar neighborhood between 5×10^8 and 10^9 yr ago. The ratio of G0/3 stars between the isochrones for 2 and 5×10^8 yr in Fig. 3 may reflect a change in the evolutionary rate in this region.

TABLE 16. G0/3 I stars.

HD	E (b-v)	(R-I) ₀	(C _m) ₀	δ(45-48) ₀	Δ(u-b)	V ₀	D00	M _v	4C	ACH	μ ₀ /μ _s 0.001	ρ km/sec	N	V km/sec	M	Sp.T.	s ¹	Note
4362	0 ^m .198	0 ^m .230	0 ^m .051	0 ^m .055	0 ^m .242	5 ^m .55	-3 ^m .92	-3 ^m .60		-0 ^m .028	-5/-4	-14.9	-22.3	-4.5	-12.7	G0 Ib	8	
16901	0.124	0.186	0.029	0.049	0.302	4.91	-4.07	-4.07		0.007	5/-7	-3.5	+5.7	-18.2	-13.6	G0 Ib	3	
26630	0.187	0.206	0.046	0.044	0.195	3.35	-3.76	-3.40		-0.002	5/-18	+7.7	+14.7	-13.4	-10.7	G0 Ib	3	X
31910	0.102	0.215	0.066	0.037	0.220	3.61	-3.60	-3.52		0.006	-6/-16	-1.7	+8.1	-9.4	-19.3	G8 Ib/11	3	X
36891	0.173	0.253	0.142	0.028	--	5.35	-3.33	--		0.033	0/-1	-18.2	-17.2	-5.4	-2.7	G2 Ib	8	
56695	0.127	0.225	0.114	0.031	0.194	8.81	-3.46	-3.33		(0.041)	--	--	--	--	--	G6 II	5	
57146	0.068	0.249	0.127	0.039	0.248	5.01	-3.58	-3.59		0.023	-5/8	+32.3	+36.8	-15.2	-6.4	G2 Ib	3	
58526	0.074	0.241	0.098	0.030	0.276	5.58	-3.40	-3.78		0.005	-7/2	+14.1	+22.4	0.0	-15.8	G3 Ib	8	
59890	0.070	0.235	0.086	0.039	0.313	4.36	-3.80	-4.00		0.000	-9/-1	+14.4	+11.3	-8.5	-17.9	G3 Ib	8	
67594	0.063	0.257	0.130	0.035	0.267	4.09	-3.46	-3.68		0.016	-18/-5	+29.6	+30.6	-20.4	19.1	G2 Ib	3	
79737	0.299	0.255	0.082	0.084	0.333	6.23	-4.44	-4.08		(-0.050)	--	--	--	--	--	G2 Ib	1	
79739	0.192	0.268	0.118	0.046	0.262	8.16	-3.65	-3.63		-0.010	--	--	--	--	--	G2 Ib	1	
87323	0.091	0.265	0.115	0.043	0.300	7.08	-3.60	-3.86		-0.010	--	--	--	--	--	G2 Ib	6	
88056	0.099	0.210	0.041	0.047	0.198	7.93	-3.80	-3.40		-0.012	--	--	--	--	--	G0 Ib	6	
88069	0.109	0.199	0.028	0.039	0.257	7.76	-3.68	-3.77		-0.011	--	--	--	--	--	G0 Ib	6	
88092	0.112	0.179	0.010	0.040	0.264	7.14	-3.75	-3.86		-0.003	--	--	--	--	--	G0 Ib	6	
94584	0.187	0.271	0.133	0.059	0.345	7.85	-3.86	-4.10		0.000	--	--	--	--	--	G0 Ib/11	6	
96746	0.102	0.223	0.063	0.031	0.249	8.38	-3.46	-3.66		-0.007	--	--	--	--	--	G2 Iab	4	
101314	0.131	0.252	0.107	0.039	0.320	6.61	-3.55	-4.00		-0.001	--	--	--	--	--	G2 Ib	6	
107285	0.215	0.241	0.070	0.055	0.356	6.82	-3.90	-4.19		-0.023	--	--	--	--	--	G2 Iab/b	6	
108282	0.218	0.166	-0.021	0.039	0.174	7.04	-3.76	-3.36		-0.016	--	--	--	--	--	G0 Ib	6	
121978	0.146	0.249	0.096	0.049	0.230	7.32	-3.76	-3.48		-0.008	--	--	--	--	--	G3 Ib/11	6	
141120	0.180	0.249	0.089	0.051	0.334	6.83	-3.80	-4.10		-0.015	--	--	--	--	--	G3 Ib/11	6	
142822	0.270	0.236	0.129	0.044	(-0.162)	6.22	-3.69	(-1.20)		(0.042)	--	--	--	--	--	G3/5 II	1	X
159187	0.079	0.259	0.098	0.027	--	2.46	-3.29	--		-0.019	-16/15	-20.2	+13.4	-20.8	-1.9	G2 Ib-11	3	
163413	0.101	0.241	0.104	0.040	0.312	6.63	-3.60	-3.99		0.011	--	--	--	--	--	G0 Ib/11	1	
165833	0.257	0.252	0.088	0.065	(0.413)	6.79	-3.65	(-4.55)		0.016	--	--	--	--	--	G3 Ib	4	X
168356	0.158	0.207	0.047	0.050	0.289	6.74	-3.88	-3.94		-0.002	--	--	--	--	--	G3 Iab	4	
178937	0.167	0.195	0.004	0.064	0.151	5.15	-4.19	(-3.15)		-0.030	--	--	--	--	--	G0 Ib/1	5	
183791	0.193	0.233	0.070	0.054	0.231	7.24	-3.90	-3.55		-0.013	--	+15	--	--	--	G2 II	9	

Notes to TABLE

1 S
 References for spectral types (see notes to Table 12).
 Sp.B., P = 263.2d.
 V = 3.4 mag, F0 IV 3 arcsec distant.
 C - indicates a CH+(Ba II) or composite spectrum.
 A possible CH- (weak G band) star.
 Sp.B., P = 251.0d. Probably an early type companion contaminating (u-b).
 Common motion.

TABLE 17. Stars in Table 16 with Geneva photometry.

HD	m_2	OBS	Del	(R-I) ₀	Δm_2	ΔDel	COMP	m_2	o-c
4362	-0 ^m .288	0 ^m .336	0 ^m .230	-0 ^m .042	-0 ^m .077	+0 ^m .293	+0 ^m .005		
16901	-0.290	0.430	0.186	+0.042	+0.094	-0.273	-0.019		
31910	-0.297	0.345	0.215	-0.021	-0.044	-0.302	+0.005		
57146	-0.244	0.384	0.269	-0.035	-0.031	-0.245	+0.001		
58526	-0.249	0.375	0.261	-0.024	-0.056	-0.259	+0.010		
59890	-0.236	0.419	0.235	+0.001	-0.002	-0.238	+0.001		
67594	-0.230	0.403	0.257	-0.036	-0.053	-0.226	-0.004		
87323	-0.229	0.393	0.265	-0.051	-0.076	-0.224	-0.005		
88069	-0.297	0.360	0.199	+0.010	-0.003	-0.308	+0.011		
88092	-0.318	0.371	0.179	+0.028	+0.040	-0.320	+0.002		
96746	-0.293	0.340	0.223	-0.033	-0.062	-0.298	+0.005		
101314	-0.234	0.402	0.252	-0.030	-0.046	-0.231	-0.003		
107285	-0.234	0.377	0.241	-0.049	-0.054	-0.257	-0.017		
108282	-0.394	0.211	0.166	-0.023	-0.100	-0.432	(+0.038)		
159181	-0.281	0.307	0.259	-0.091	-0.152	-0.284	+0.003		
192876	-0.217	0.401	0.256	-0.021	-0.054	-0.228	+0.011		
204867	-0.284	0.392	0.200	+0.021	+0.027	+0.287	+0.003		
209750	-0.214	0.422	0.245	+0.003	-0.015	-0.226	± 0.012		
						mean	+0.001		
						σ	± 0.009		

7. SUMMARY

(1) The luminosity, reddening, and heavy element abundances are derived from 250 bright giants and supergiants of types G and K.

(2) On the basis of stellar models with convective overshoot at the cores, the ages of the BG and SG in clusters are near 2×10^8 yr for NGC 2437, 3×10^8 yr for NGC 2516 and 3114, and 4×10^8 yr for NGC 2287.

(3) BG with an age between 5×10^8 and 10^9 yr, or roughly between the ages of M11 and the Hyades, are very scarce in the solar neighborhood. The G0/3 stars (Hertzsprung Gap) with $M_V > -2.5$ mag ($t \sim 2 \times 10^8$ yr) are also extremely rare.

(4) The space motions of the BG and SG of types G5 to K1, $(R-I) = 0.275$ to 0.425 mag, have median values of $(U, V, W) = (+10.6, -13.2, -7.7) \pm (12.3, 8.8, 8.8)$ km/s.

(5) The M_1 index reflects only the luminosity of GK stars, in contrast to its sensitivity to heavy element abundance in the F stars.

(6) The CN index of the DDO system does reflect the heavy element abundance with a dozen stars, also analyzed spectroscopically by McWilliam (1990), giving $P[\text{Fe}/\text{H}] = 5.0 \text{ CN} - 0.12$ (Fig. 6) and a dispersion of 0.06 dex. However, a few stars analyzed by Luck & Bond (1989) show very large deviations from this correlation.

(7) The correlation of $[\text{Fe}/\text{H}]$ with ΔCN for 100 normal

(class III) giants analyzed by McWilliam is well defined and almost precisely mirrored by 31 luminosity class III stars in common with a spectroscopic analyses by Brown *et al.* (1989). However, the same study by Brown *et al.* contains 17 SG and BG in common with Table 6 and these depart dramatically from the $(\Delta \text{CN}, [\text{Fe}/\text{H}])$ correlation for the BG and SG stars analyzed by McWilliam (Fig. 6). In Fig. 6, the Brown *et al.* results appear to define a different slope to the correlation, but except for three or four objects, a zero-point displacement of about 0.25 dex is a more likely explanation. The correlation of T_e with $R-I$ indicates that difficulties in the assumed temperatures are not sufficient to explain the difference in the spectroscopic determinations of $[\text{Fe}/\text{H}]$.

(8) The BG and SG show a distribution of $P[\text{Fe}/\text{H}]$, from ΔCN , with a sharp peak between -0.1 and -0.2 dex. The F type BG and SG (Paper II) give a very similar distribution but with a peak between $+0.1$ and $+0.2$ dex. It may not be an accident that this displacement is the same as that in the zero-points of the spectroscopically determined $[\text{Fe}/\text{H}]$ values (Fig. 6).

(9) The mean values of $P[\text{Fe}/\text{H}]$, grouped in 100 pc steps from the Sun in the direction of the galactic center, show no correlation with distances over 1 kpc near the Sun (Fig. 8). The mean values show a range over this distance that is less than one third the dispersion of the individual means. Eight stars between 300 and 900 pc from the Sun in the direction away from the galactic center agree with the mean value near the Sun, but 15 stars more than 500 pc in the direction of the galactic center give a mean value about 0.1 dex smaller, although with a dispersion of ± 0.18 dex.

(10) Some 20 stars, spectroscopically classified as BG or SG, are photometrically identified as normal (class III) giants.

(11) The G0/3 stars are in the temperature range, $R-I = 0.15$ to 0.27 mag ($T_e \sim 5600^\circ$ to 5000°), where the sensitivity of the photometric indices to the luminosity is subject to relatively rapid changes. The long period Cepheids ($P > 10$ d) lie in this range, and the luminosities from the PL relation, are well represented by the luminosity calibrations adopted here.

(12) The G0/3 stars, like the GK objects, have M_1 (and m_2) indices that are apparently sensitive only to luminosity,

TABLE 18. G0/3 II stars.

HD	$E(b-y)$	(R-I) ₀	(C _m) ₀	$\delta(45-48)$ ₀	$\delta(u-b)$	V_0	DDO	M_V	4C	ΔCN	Sp. T.	S ¹
63609	0 ^m .127	0 ^m .228	0 ^m .083	0 ^m .005	0 ^m .084	7 ^m .75	-2 ^m .31	-2 ^m .44	0 ^m .007	G2 II	6	
70046	0.191	0.236	0.065	0.002	0.018	8.12	-2.18	-2.27	-0.022	G3 Ib	1	
74395	0.077	0.212	0.069	0.022	0.122	4.31	-2.98	-2.94	0.013	G1 Ib	3	
79698	0.048	0.244	0.121	0.004	0.105	5.33	-2.24	-2.75	0.024	G6 II	6	
83609	0.069	0.224	0.067	0.016	0.062	7.74	-2.23	-2.55	-0.004	G0 Ib	5	
84441	0.053	0.226	0.074	0.011	0.079	2.67	-2.54	-2.65	0.000	G1 II	3	
87951	0.093	0.746	0.106	0.008	0.088	8.36	-2.35	-2.65	0.006	G3/5 II	6	
119605	0.078	0.213	0.052	0.017	0.037	5.28	-2.80	-2.44	-0.005	G0 Ib-II	3	
132594	0.128	0.248	0.045	0.006	0.023	7.53	-2.30	-2.26	(-0.056)	G5 II	6	
199997	0.057	0.221	0.085	0.017	0.096	7.45	-2.78	-2.76	0.018	G1 II	6	
222574	0.077	0.208	0.050	0.025	0.163	4.51	-3.10	-3.19	0.000	G2 Ib/II	4	

¹ S Reference to spectral type (see notes to Table 12).

unlike the GF stars. The ΔCN indices may also be sensitive only to luminosity.

(13) The correlation of ΔM_1 with the amplitude defect in the B light curves of Cepheids, F_B , was previously found and the (PLF_B) relation interpreted as a $(PL[\text{Fe}/\text{H}])$ relation. The correlation between F_B and ΔM_1 is greatly differ-

ent for the LPC, which lie in the temperature domain discussed here, than for the SPC, which are hotter. The hotter (F type) show a correlation between M_1 and heavy element abundance, whereas the LPC (G type) do not, so the correlation between F_B and ΔM_1 obviously needs further examination.

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