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RED AND INFRARED MAGNITUDES FOR 282 STARS WITH KNOWN TRIGONOMETRIC PARALLAXES *

BY GERALD E. KRON, S.C.B. GASCOIGNE, AND HOWARD S. WHITE

Abstract. Photoelectric red and infrared magnitudes have been obtained for 282 stars listed in the Yale *General Catalogue of Trigonometric Stellar Parallaxes* (Jenkins 1952). All but 21 of the 165 stars in this catalogue with parallaxes 0″.100 or greater were observed. The remaining stars on the program, with parallaxes less than 0″.100, were observed to fill out a color-luminosity diagram, or for other reasons. A high degree of correlation was found between the *R-I* colors and the luminosities of nearby stars for certain ranges of spectral type. When the *R-I* colors are compared with the *P-V* colors of the same stars, a scatter in excess of the observational error is found. This scatter may be caused by inherent but superficial properties of the stars themselves. It is concluded that colors measured on any arbitrary system may not in some instances bear a simple relationship with luminosity, even for ultraviolet-free measurements of nearby main-sequence stars.

Introduction. The program resulting in the magnitudes presented here was started by the senior author in 1949 as a result of interest stimulated by the color-magnitude work at this observatory by Eggen (1950). A few measurements on nearby stars, made in 1949 on a red-infrared photometric system, indicated that such a system would have the useful property of giving unusually good color resolution of the M dwarf stars. In addition, the relatively small atmospheric extinction gives photometric results relatively free from errors introduced in extinction correction. For these reasons we deemed it worth while to reobserve the magnitudes and colors of some of the stars in the region of the sun on a red-infrared system.

The loss of color resolution on a blue-yellow system for the late-type dwarfs is well illustrated by Eggen's data (1950) and by the more recent photometric data of Yates (1954). Both Eggen and Yates give plots that show this effect, with decreasing absolute magnitude and with advancing spectral type. Recently, Mumford (1956) published observations of 166 red dwarf stars, many of them newly discovered objects not measured by other observers. When Mumford's observations alone are grouped according to spectral type as in Table I, we find:

TABLE I. RED DWARF COLORS AS OBSERVED BY MUMFORD

No. of stars	Type	*B-V*	Δm
47	K8	$1^m.16$	$0^m.20$
85	M0	1.36	0.14
27	M2	1.50	0.05
5	M5	1.55	

The loss in color resolution with advancing spectral type is quite apparent, and it is even more conspicuous when Mumford's *B-V* colors are transformed back to his original photoelectric system by means of his equation (1), a non-linear transformation which further decreases the color resolution.

Observational technique. In order to maintain a stable magnitude and color system over the entire sky in a new and radically different color system, it became necessary to establish stellar photometric standards, so that zero point and color properties could be maintained in spite of changes in photometric equipment. Results for these standards which consist, for zero-point, of two groups of stars of limited color range in small regions and, for extension of the color range, of stars in an equatorial band, have already been published along with discussions of methods,

* *Lick Observatory Bulletin*, No. 556.

equipment used, and observing technique (Kron and Smith 1951; Kron, Gascoigne and White 1953). Three telescopes were used: the Crossley reflector (Newtonian focus) and the 36-inch refractor at the Lick Observatory, and the 29-inch Reynolds reflector (Newtonian focus) at the Commonwealth Observatory, Mt. Stromlo, Australia. Two CE-25 photocells of almost identical color characteristics were employed. All the work was done with the same two filters described in the 1953 paper on the standards; all measurements in the red were made with an interference filter (Smith 1951). Single stars, and pairs whose total light was measured as a single star, were observed through focal-plane apertures of about 30 seconds of arc. When the components of "close" double stars, such as α Centauri and γ Virginis, were measured separately, smaller holes were used, the size depending upon the separation and the ratio of light of the two components. In such cases, the total light was also measured through the 30″ inclusive aperture, and the individual magnitudes and colors were obtained by proper combination with the difference as measured through the appropriate smaller exclusive aperture. By this method, systematic error caused by failure of small apertures to admit as much light as large ones was avoided.

The sensitivity range of our photometer was too small to measure several important very bright stars in the southern hemisphere, partly because of the low extinction value of the available objective screen. For such stars, a program star of similar spectral type was selected as a secondary standard, and the very bright star was measured differentially at reduced voltage on the photocell. This work was done with sufficient care to convince us that the loss in accuracy was trivial. Changes in equipment were also made with due consideration of possible effects on accuracy, and they were always accompanied by generous overlap and reference to standards. Except for some difficulty with Barnard's star, our color transformations were stable, and the observations apparently went so well that we do not feel the necessity for a detailed discussion. Barnard's star was measured on seven nights, but only three measurements made with the Reynolds reflector in 1951 are included in the accompanying table. Since the other measurements are discordant by as much as 0.2 mag., it seems probable that Barnard's star is a variable.

We were unable to find four red dwarfs, of only routine interest, which we otherwise would have measured. In the case of the two interesting red dwarfs Proxima Centauri (No. 3278) and Wolf 359 (No. 2553), Dr. A. D. Thackeray kindly furnished us with a finding chart for Proxima, and we are indebted to Miss Sarah Lee Lippincott for a chart for Wolf 359. Dr. Joy provided information for several other difficult stars, of which Wolf 47 (No. 205) was one.

Errors. Experimental errors can be appraised from the sizes of the average deviations and from the number of observations, as given in Table II. The systematic errors are much more difficult to evaluate quantitatively. We have depended much on the considerable work expended in establishing the standards, on generous use of these standards, and on frequent repetition of measurements of each star to reduce, control, and reveal systematic errors. Probably atmospheric extinction may be dismissed as a source of systematic error, partly because of its small size, and partly because repetition of many of the measures from opposite hemispheres gave definite evidence that errors from this source were negligible. In the absence of independent data for comparison, we can only guess at the size of any other systematic errors in the present material. In the magnitudes there are undoubtedly some errors of 0.02 mag., a few of 0.03 mag., and, we hope, very few as large as 0.04 mag. The systematic errors in the colors probably are smaller than those in the magnitudes.

The observations. These are given in Table II, where the first column contains the serial number from the Yale parallax catalogue for all but one star. An asterisk after this number indicates that a note appears at the end of the table. The second, third, and fourth columns are self-explanatory. The fifth column contains the trigonometric parallax with its probable error, as given in the Yale catalogue, except for a few stars for which, according to the Notes, recently published parallaxes have been included. A dagger after the parallax indicates that we have assumed systemic relation for more than one star, and have ourselves combined more than one parallax into the mean value preceding the dagger. This mean is a weighted average computed from the probable errors of the individual parallaxes. The sixth column lists for each star the number of nights on which it was observed. The seventh and eighth columns contain respectively the mean apparent red magnitude, and the mean *R-I* color index along with the average deviation of a single observation from the mean, for each entry. The ninth column contains the absolute red magnitude, computed from the parallax and the apparent red magnitude. The tenth and last column

TABLE II. RED AND INFRARED MAGNITUDES FOR 282 NEARBY STARS

Yale No.	Name	α(1900)	δ(1900)	π ± p.e.	n	R ± a.d.	(R-I) ± a.d.	M_R	e
		h m		"		m	m	m	
3	-68°3597	0 00.2	-68°22'	0.072 ± 8	6	+ 7.89 ± 3	+0.42 ± 2	+ 7.18	7
49*	+43°44 A	0 12.7	+43 27	.278 ± 7	4	+ 7.03 ± 2	+0.88 ± 2	+ 9.25	3
	+43°44 B				4	+ 9.60 ± 4	+1.22 ± 5	+11.82	7
54	ζ Tuc	0 14.9	-65 28	.134 ± 8	3	+ 4.02 ± 2	+0.22 ± 1	+ 4.66	4
69*	β Hyi	0 20.5	-77 49	.153 ± 7	3	+ 2.59 ± 2	+0.23 ± 0	+ 3.51	2
102	LDS 21 A	0 31.8	-49 41	.033 ± 12	3	+ 6.57 ± 2	+0.21 ± 1	+ 4.16	17
	LDS 21 B				3	+ 8.10 ± 2	+0.27 ± 2	+ 5.69	18
110	54 Psc	0 34.2	+20 43	.100 ± 6	3	+ 5.52 ± 2	+0.27 ± 2	+ 5.52	5
155*	η Cas A	0 43.0	+57 17	.182 ± 5	5	+ 3.30 ± 2	+0.22 ± 1	+ 4.60	2
	η Cas B				5	+ 6.42 ± 2	+0.59 ± 1	+ 7.72	2
156	+ 4°123	0 43.1	+04 46	.145 ± 5	8	+ 5.32 ± 1	+0.33 ± 1	+ 6.13	2
177*	-31°325	0 48.1	-30 54	.103 ± 11	3	+ 6.71 ± 1	+0.34 ± 1	+ 6.77	6
202	+70°68	0 55.3	+71 09	.108 ± 6	3	+ 8.77 ± 1	+1.08 ± 1	+ 8.93	4
204	Wolf 46 A	0 56.3	+61 48	.107 ± 7†	5	+ 8.47 ± 2	+0.89 ± 2	+ 8.61	5
205	Wolf 47 B	0 57.0	+61 50		5	+11.98 ± 6	+1.52 ± 8	+12.12	11
219*	μ Cas	1 01.6	+54 26	.136 ± 6	4	+ 4.86 ± 2	+0.28 ± 2	+ 5.53	4
246	-68°41	1 06.7	-68 00	.108 ± 12	4	+ 8.55 ± 2	+1.07 ± 2	+ 8.71	7
328*	-30°529	1 30.4	-30 25	.053 ± 7	4	+ 6.64 ± 2	+0.40 ± 1	+ 5.26	7
-- *	L726-8	1 34.0	-18 28	.410 ± 25	4	+10.00 ± 14	+1.70 ± 2	+13.01	6
344	α Eri	1 34.0	-57 45	.023 ± 12	3	+ 0.65 ± 1	-0.15 ± 1	- 2.54	24
352*	p Eri AB	1 36.0	-56 42	.148 ± 7	3	+ 4.70 ± 1	+0.33 ± 1	+ 5.55	3
356	107 Psc	1 37.1	+19 47	.133 ± 6	3	+ 4.87 ± 1	+0.29 ± 1	+ 5.49	3
365	τ Cet	1 39.4	-16 28	.275 ± 5	5	+ 3.16 ± 2	+0.26 ± 1	+ 5.36	2
371	+63°238	1 40.5	+63 22	.111 ± 6	3	+ 5.29 ± 1	+0.26 ± 2	+ 5.51	5
394*	β Ari	1 49.1	+20 19	.063 ± 5	3	+ 2.75 ± 2	-0.02 ± 0	+ 1.75	4
431	-18°359	2 00.1	-18 06	.109 ± 6	4	+ 9.00 ± 1	+1.02 ± 2	+ 9.18	4
450*	+ 2°348	2 07.4	+03 10	.092 ± 8	5	+ 9.02 ± 3	+0.86 ± 1	+ 8.84	5
456	66 Cet A	2 07.7	-02 52	.043 ± 5	4	+ 5.48 ± 1	+0.19 ± 1	+ 3.65	6
	66 Cet B				4	+ 7.44 ± 1	+0.24 ± 2	+ 5.61	7
488	κ For	2 18.0	-24 16	.070 ± 8	3	+ 4.95 ± 2	+0.24 ± 1	+ 4.18	6
501	ξ^2 Cet	2 22.8	+08 01	.022 ± 6	3	+ 4.45 ± 3	-0.13 ± 1	+ 1.16	13
520*	HR 753 A	2 30.6	+06 25	.147 ± 5	6	+ 5.36 ± 2	+0.36 ± 1	+ 6.20	2
	HR 753 B				6	+10.26 ± 3	+1.28 ± 2	+11.10	3
522	-44°775	2 30.6	-44 14	.076 ± 13	3	+ 7.94 ± 3	+0.78 ± 2	+ 7.34	10
549*	θ Per AB	2 37.4	+48 48	.077 ± 5	3	+ 3.94 ± 1	+0.18 ± 1	+ 3.37	4
555	20 C 180	2 38.4	+25 06	.130 ± 8	4	+ 9.31 ± 2	+1.08 ± 1	+ 9.88	4
558	μ Cet	2 39.5	+09 42	.040 ± 6	3	+ 4.19 ± 2	+0.05 ± 1	+ 2.20	8
599	HR 857	2 47.7	-13 11	.127 ± 6	3	+ 5.67 ± 1	+0.32 ± 1	+ 6.19	3
647*	ι Per	3 01.8	+49 14	.084 ± 5	4	+ 3.83 ± 2	+0.20 ± 2	+ 3.45	5
664*	α For AB	3 07.8	-29 23	.070 ± 6	4	+ 3.68 ± 2	+0.20 ± 2	+ 2.91	6
691	κ_1 Cet	3 14.1	+03 00	.105 ± 6	8	+ 4.57 ± 4	+0.22 ± 1	+ 4.67	4
701	ζ^1 Ret B	3 15.6	-62 57	.102 ± 8†	7	+ 5.29 ± 2	+0.23 ± 1	+ 5.33	4
703*	82 Eri	3 15.9	-43 27	.156 ± 8	6	+ 3.99 ± 2	+0.28 ± 1	+ 4.96	3
705	ζ^2 Ret A	3 16.0	-62 53		7	+ 5.04 ± 2	+0.23 ± 1	+ 5.08	4
724	-20°643	3 23.3	-20 10	.066 ± 6	3	+ 7.62 ± 2	+0.57 ± 1	+ 6.72	5
734	-63°231	3 25.3	-63 50	.060 ± 7	3	+ 7.52 ± 1	+0.43 ± 1	+ 6.41	6
742	ε Eri	3 28.2	-09 48	.303 ± 4	4	+ 3.33 ± 2	+0.30 ± 1	+ 5.74	2
754*	-48°1011	3 31.9	-48 46	.083 ± 7	4	+ 7.81 ± 1	+0.58 ± 1	+ 7.41	5
788	δ Eri	3 38.5	-10 06	.109 ± 4	4	+ 3.15 ± 2	+0.32 ± 2	+ 3.33	4
873*	- 1°565 AB	3 52.5	-01 26	.097 ± 12	5	+ 7.38 ± 4	+0.49 ± 3	+ 7.31	9
945*	o_2^2 Eri A	4 10.7	-07 49	.200 ± 4	3	+ 4.07 ± 3	+0.31 ± 2	+ 5.57	4
	o^2 Eri BC				3	+ 8.99 ± 4	+0.83 ± 2	+10.49	4
992	Ross 594	4 23.6	+39 39	.095 ± 14	4	+12.27 ± 5	+1.46 ± 4	+12.16	11
1046	+18°683	4 37.0	+18 47	.098 ± 6	3	+ 8.79 ± 1	+0.96 ± 1	+ 8.75	4
1070	-17°954	4 43.1	-17 07	.066 ± 7	3	+ 5.25 ± 3	+0.23 ± 2	+ 4.35	7

TABLE II (continued)

Yale No.	Name	α(1900)	δ(1900)	π ± p.e.	n	R ± a.d.	(R-I) ± a.d.	M_R	e
		h m	° '	"		m	m	m	
1077	π^3 Ori	$4^h44.4^m$	+06°47'	0.125 ± 5	5	+ 3.05 ± 2	+0.16 ± 2	+ 3.53	4
1129*	- 5°1123	4 55.9	-05 52	.104 ± 4	3	+ 5.70 ± 2	+0.35 ± 1	+ 5.78	3
1135*	-21°1051	4 58.2	-21 24	.128 ± 8	3	+ 7.33 ± 1	+0.72 ± 1	+ 7.87	4
1158	β Eri	5 02.9	-05 13	.042 ± 4	5	+ 2.82 ± 3	-0.01 ± 2	+ 0.94	6
1164	ζ Dor	5 03.8	-57 37	.078 ± 8	3	+ 4.52 ± 2	+0.20 ± 2	+ 3.98	7
1181*	-45°1841	5 07.7	-44 59	.251 ± 7	7	+ 7.84 ± 2	+0.77 ± 2	+ 9.84	3
1187*	α Aur AB	5 09.3	+45 54	.072 ± 3†	3	- 0.25 ± 2	+0.28 ± 1	- 0.96	3
1193*	ADS 3841 AB	5 10.0	+45 44		3	+ 9.01 ± 3	+0.94 ± 1	+ 8.30	3
1199*	λ Aur	5 12.1	+40 01	.066 ± 6	5	+ 4.45 ± 2	+0.20 ± 2	+ 3.55	6
1229	γ Ori	5 19.8	+06 16	.026 ± 10	4	+ 1.84 ± 3	-0.25 ± 1	- 1.08	18
1242	- 3°1110	5 23.5	-03 34	.071 ± 6	4	+ 7.02 ± 2	+0.43 ± 2	+ 6.28	6
1255	- 3°1123	5 26.4	-03 42	.163 ± 5	5	+ 6.87 ± 2	+0.84 ± 1	+ 7.93	2
1279*	ι Ori	5 30.5	-05 59	.021 ± 12	4	+ 2.95 ± 3	-0.24 ± 1	- 0.44	26
1289	+53°934 A	5 33.2	+53 26	.095 ± 6†	4	+ 5.86 ± 2	+0.30 ± 1	+ 5.75	4
1291	+53°935 B	5 33.4	+53 27		4	+ 8.71 ± 2	+0.82 ± 1	+ 8.60	4
1301*	ζ Ori AB	5 35.7	-02 00	.022 ± 11	4	+ 1.96 ± 2	-0.22 ± 2	- 1.33	24
1305*	Ross 47	5 36.4	+12 29	.165 ± 5	4	+10.03 ± 2	+1.27 ± 2	+11.11	4
1316	γ Lep A	5 40.3	-22 29	.122 ± 6	4	+ 3.39 ± 3	+0.16 ± 1	+ 3.82	3
	γ Lep B				4	+ 5.68 ± 3	+0.34 ± 2	+ 6.11	4
1326	ζ Lep	5 42.4	-14 52	.042 ± 7	4	+ 3.61 ± 2	-0.05 ± 1	+ 1.73	9
1341*	-70°447	5 45.7	-70 13	.041 ± 8	4	+ 7.73 ± 3	+0.27 ± 1	+ 5.79	10
1354	χ^1 Ori	5 48.5	+20 15	.101 ± 6	4	+ 4.16 ± 1	+0.20 ± 1	+ 4.18	4
1426	Ross 79	6 05.4	+10 22	.101 ± 7	4	+ 9.20 ± 3	+1.02 ± 3	+ 9.22	6
1430	-21°1377	6 06.4	-21 49	.170 ± 6	7	+ 7.09 ± 1	+0.82 ± 1	+ 8.24	2
1468	α Men	6 13.2	-74 43	.115 ± 11	5	+ 4.76 ± 2	+0.21 ± 1	+ 5.06	5
1509*	Ross 614	6 24.3	-02 44	.250 ± 5	5	+ 9.43 ± 3	+1.38 ± 2	+11.42	3
1538*	+17°1320	6 31.5	+17 38	.097 ± 6	4	+ 8.64 ± 2	+0.74 ± 1	+ 8.57	4
1539*	γ Gem	6 31.9	+16 29	.031 ± 6	4	+ 2.02 ± 2	-0.09 ± 1	- 0.52	10
1577*	α CMa AB	6 40.7	-16 35	.375 ± 4	3	- 1.25 ± 3	-0.12 ± 1	+ 1.62	2
1606	- 5°1844 A	6 47.4	-05 03	.096 ± 6	7	+ 6.01 ± 4	+0.38 ± 1	+ 5.92	4
	- 5°1844 B				3	+ 8.86 ± 2	+0.93 ± 1	+ 8.77	4
1609*	20 C 400	6 48.4	+33 24	.170 ± 5	4	+ 8.72 ± 1	+1.08 ± 2	+ 9.87	4
1660	-43°2904 C	7 00.8	-43 25	.045 ± 6†	2	+ 8.04 ± 2	+0.50 ± 1	+ 6.31	7
1662	-43°2906 A	7 00.9	-43 28		2	+ 5.33 ± 2	+0.22 ± 2	+ 3.60	9
	-43°2907 B				2	+ 6.54 ± 2	+0.28 ± 1	+ 4.81	7
1668*	Ross 986	7 03.3	+38 43	.148 ± 11	3	+ 9.93 ± 1	+1.39 ± 2	+10.78	6
1708*	λ Gem AB	7 12.3	+16 43	.041 ± 5	5	+ 3.64 ± 3	-0.05 ± 2	+ 1.70	7
1718*	δ Gem AB	7 14.2	+22 10	.059 ± 5	6	+ 3.42 ± 4	+0.10 ± 2	+ 2.28	6
1755*	+ 5°1668	7 22.0	+05 31	.263 ± 4	6	+ 8.40 ± 3	+1.19 ± 1	+10.50	2
1774*	+36°1638 A	7 25.4	+36 26	.087 ± 7	4	+ 9.25 ± 6	+1.04 ± 3	+ 8.95	7
	Ross 989 B				3	+10.27 ± 7	+1.23 ± 4	+ 9.97	9
1785*	YY Gem	7 28.2	+32 06	.072 ± 4	3	+ 8.05 ± 5	+0.78 ± 1	+ 7.34	4
1805*	α CMi AB	7 34.1	+05 29	.286 ± 4	3	+ 0.26 ± 2	+0.14 ± 1	+ 2.54	2
1809*	- 3°2001 A	7 35.0	-03 22	.081 ± 8	4	+ 6.71 ± 2	+0.32 ± 1	+ 6.25	5
	- 3°2002 B				4	+ 8.08 ± 3	+0.56 ± 2	+ 7.62	6
1827*	Ross 882	7 39.4	+03 48	.149 ± 6	6	+ 9.76 ± 4	+1.40 ± 3	+10.63	5
1942*	Ross 619	8 06.5	+09 11	.151 ± 7	3	+11.26 ± 6	+1.30 ± 2	+12.16	5
2098*	δ Vel AB	8 41.9	-54 21	.043 ± 7	3	+ 2.03 ± 1	-0.07 ± 1	+ 0.20	8
2113*	+71°482 AB	8 46.0	+71 11	.089 ± 4	3	+ 7.17 ± 1	+0.62 ± 2	+ 6.92	5
2198	+53°1320 A	9 07.6	+53 07	.163 ± 5	4	+ 6.76 ± 3	+0.68 ± 2	+ 7.82	4
	+53°1321 B				4	+ 6.84 ± 2	+0.69 ± 3	+ 7.90	5
2213	β Car	9 12.1	-69 18	.038 ± 10	3	+ 1.78 ± 1	-0.07 ± 1	- 0.32	13
2238	-59°1362	9 19.2	-59 51	.135 ± 13	2	+ 8.46 ± 1	+0.79 ± 0	+ 9.11	4
2254	Ross 439	9 24.0	-06 55	.061 ± 8	5	+10.94 ± 3	+1.09 ± 3	+ 9.87	9
2267*	-12°2918	9 26.4	-13 03	0.106 ± 6	3	+ 8.84 ± 1	+1.04 ± 1	+ 8.96	4

TABLE II. (continued)

Yale No.	Name	α(1900)	δ(1900)	π ± p.e.	n	R ± a.d.	(R-I) ± a.d.	M_R	e
		h m				m	m	m	
2280*	+36°1979 AB	9 29.7	+36°16'	0".107 ± 5	2	+ 5.06 ± 1	+0.26 ± 0	+ 5.20	2
2313*	-45°5378	9 40.8	-45 18	.100 ± 7	4	+ 9.00 ± 3	+0.96 ± 1	+ 9.00	4
2361	-45°5627	9 54.6	-45 56	.054 ± 8	4	+ 9.93 ± 2	+1.20 ± 1	+ 8.59	8
2379*	+75°403	10 01.7	+75 37	.052 ± 11	4	+ 8.63 ± 1	+0.59 ± 1	+ 7.21	10
2384*	α Leo A	10 03.0	+12 27	.039 ± 7	3	+ 1.48 ± 3	-0.17 ± 1	- 0.56	10
	α Leo BC				2	+ 7.67 ± 0	+0.32 ± 1	+ 5.63	10
2390	Gmb 1618	10 05.3	+49 58	.222 ± 5	4	+ 5.74 ± 2	+0.60 ± 1	+ 7.47	2
2420*	+20°2465	10 14.2	+20 22	.212 ± 5	5	+ 8.08 ± 1	+1.12 ± 2	+ 9.71	3
2456	+ 1°2447	10 23.9	+01 22	.128 ± 8	5	+ 8.49 ± 2	+0.95 ± 2	+ 9.03	5
2457	36 UMa B	10 24.0	+56 30	.082 ± 5†	4	+ 7.84 ± 2	+0.54 ± 2	+ 7.41	5
2459	36 UMa A	10 24.2	+56 30		4	+ 4.64 ± 2	+0.16 ± 1	+ 4.21	4
2524*	Wolf 358	10 45.8	+07 22	.139 ± 9	2	+10.20 ± 4	+1.28 ± 4	+10.92	9
2553*	Wolf 359	10 51.6	+07 37	.419 ± 8	3	+11.28 ± 1	+1.85 ± 1	+14.40	2
2561	20 C 601	10 54.8	+23 22	.149 ± 8	3	+ 8.82 ± 1	+1.02 ± 1	+ 9.69	4
2576*	Lal 21185	10 57.9	+36 38	.398 ± 5	3	+ 6.36 ± 1	+0.91 ± 1	+ 9.36	2
2582*	Lal 21258 A	11 00.5	+44 02	.173 ± 10	4	+ 7.68 ± 1	+0.82 ± 1	+ 8.87	4
	Lal 21258 B				4	+12.49 ± 12	+1.72 ±13	+13.68	17
2631*	+66°717	11 14.8	+66 23	.113 ± 7	4	+ 8.31 ± 2	+0.76 ± 1	+ 8.57	4
2699	61 UMa	11 35.8	+34 46	.110 ± 8	3	+ 5.01 ± 1	+0.27 ± 2	+ 5.21	6
2722*	AC +79°3888	11 41.3	+79 14	.196 ± 8	4	+ 9.44 ± 3	+1.18 ± 2	+10.90	4
2730*	Ross 128	11 42.6	+01 23	.297 ± 6	4	+ 9.55 ± 1	+1.30 ± 1	+11.92	2
2738	β Leo	11 44.0	+15 08	.076 ± 5	4	+ 2.18 ± 2	-0.06 ± 1	+ 1.58	4
2739	β Vir	11 45.5	+02 20	.098 ± 5	8	+ 3.39 ± 1	+0.16 ± 1	+ 3.35	3
2745*	Gmb 1830	11 47.2	+38 26	.116 ± 5	4	+ 6.05 ± 2	+0.29 ± 2	+ 6.37	4
2762	-26°8883	11 53.0	-27 08	.096 ± 8	4	+ 6.38 ± 2	+0.41 ± 1	+ 6.29	5
2857*	Ross 695	12 19.5	-17 38	.099 ± 12	4	+10.12 ± 2	+0.98 ± 1	+10.10	6
2890*	Wolf 424 AB	12 28.4	+09 34	.223 ± 6	4	+10.50 ± 1	+1.62 ± 3	+12.24	4
2895	β CVn	12 29.0	+41 54	.108 ± 6	5	+ 4.01 ± 3	+0.21 ± 1	+ 4.17	3
2910	-51°6859	12 32.5	-51 27	.116 ± 7	4	+ 9.41 ± 6	+1.07 ± 1	+ 9.73	4
2924	γ Vir A	12 36.6	-00 54	.101 ± 7	7	+ 3.37 ± 2	+0.11 ± 2	+ 3.39	4
	γ Vir B				7	+ 3.41 ± 2	+0.09 ± 5	+ 3.43	7
2935*	10 CVn	12 40.3	+39 49	.065 ± 7	3	+ 5.74 ± 1	+0.22 ± 1	+ 4.81	6
2943	20 C 737	12 43.0	+10 19	.107 ± 12	4	+ 9.99 ± 2	+1.21 ± 2	+10.13	7
2949	20 C 742	12 45.1	+66 40	.116 ± 10	3	+ 9.65 ± 9	+1.14 ± 3	+ 9.97	8
2951*	+ 0°2989	12 45.6	-00 13	.086 ± 6	5	+ 7.58 ± 2	+0.66 ± 2	+ 7.25	5
3015	β Com	13 07.2	+28 23	.120 ± 6	4	+ 4.05 ± 2	+0.21 ± 2	+ 4.45	4
3039	61 Vir	13 13.2	-17 45	.115 ± 6	3	+ 4.45 ± 2	+0.22 ± 1	+ 4.75	4
3063*	α Vir	13 19.9	-10 38	.019 ± 6	6	+ 1.19 ± 1	-0.26 ± 1	- 2.42	14
3074*	Ross 486 AB	13 23.2	-01 50	.100 ± 12	3	+ 9.91 ± 4	+1.11 ± 3	+ 9.91	9
3076	70 Vir	13 23.5	+14 19	.041 ± 6	7	+ 4.68 ± 1	+0.24 ± 2	+ 2.74	8
3079	+11°2576	13 24.9	+10 55	.121 ± 11	3	+ 7.99 ± 2	+0.82 ± 2	+ 8.41	7
3135*	+15°2620	13 40.7	+15 26	.211 ± 5	3	+ 7.41 ± 1	+0.85 ± 1	+ 9.03	2
3175*	η Boo	13 49.9	+18 54	.102 ± 5	4	+ 2.45 ± 2	+0.20 ± 1	+ 2.49	3
3243	-58°5467	14 12.0	-58 54	.098 ± 7	3	+ 6.18 ± 1	+0.34 ± 1	+ 6.14	5
3273*	+24°2733 A	14 21.1	+24 06	.059 ± 7	4	+ 8.74 ± 2	+0.75 ± 2	+ 7.60	7
	+24°2733 B				4	+ 8.98 ± 1	+0.80 ± 2	+ 7.84	7
3278*	20 C 861	14 22.8	-62 15	.762 ± 5	4	+ 9.02 ± 3	+1.65 ± 1	+13.44	1
3296	Wolf 1481	14 28.9	-12 06	.148 ± 8	4	+ 9.82 ± 2	+1.28 ± 1	+10.67	4
3309	α Cen A	14 32.8	-60 25	.751 ± 11	5	- 0.30 ± 1	+0.22 ± 2	+ 4.08	2
	α Cen B				5	+ 0.91 ± 2	+0.24 ± 4	+ 5.29	4
3313	α Cir A	14 34.4	-64 32	.049 ± 8	8	+ 3.17 ± 2	+0.02 ± 2	+ 1.62	9
	α Cir B				2	+ 7.71 ± 7	+0.42 ± 4	+ 6.16	14
3340	109 Vir	14 41.2	+02 19	.030 ± 5	6	+ 3.86 ± 1	-0.10 ± 2	+ 1.25	9
3350	α^1 Lib B	14 45.2	-15 35	.047 ± 6†	4	+ 5.03 ± 2	+0.11 ± 1	+ 3.39	7
3351	α^2 Lib A	14 45.3	-15 38		3	+ 2.82 ± 1	-0.03 ± 2	+ 1.18	8

TABLE II. (continued)

Yale No.	Name	α(1900)	δ(1900)	π ± p.e.	n	R ± a.d.	(R-I) ± a.d.	M_R	e
		h m				m	m	m	
3360*	ξ Boo AB	14 46.8	+19°31'	0".145 ± 4	4	+ 4.32 ± 1	+0.30 ± 1	+ 5.13	3
3375	HR 5568 A	14 51.6	-20 58	.173 ± 6	3	+ 5.20 ± 2	+0.42 ± 2	+ 6.39	4
	HR 5568 B				3	+ 7.01 ± 1	+0.89 ± 2	+ 8.20	4
3416	45 Boo	15 02.9	+25 16	.061 ± 7	3	+ 4.80 ± 1	+0.17 ± 2	+ 3.73	8
3419	+25°2874	15 03.1	+25 18	.075 ± 6	3	+ 9.16 ± 1	+0.64 ± 2	+ 8.54	6
3425*	-15°4041 B	15 04.7	-15 54	.040 ± 5	4	+ 9.00 ± 1	+0.35 ± 2	+ 7.01	8
	-15°4042 A				4	+ 8.70 ± 1	+0.32 ± 3	+ 6.71	9
3458	- 7°4003	15 14.2	-07 21	.149 ± 5	4	+ 9.26 ± 2	+1.10 ± 1	+10.13	3
3491	- 8°3981 A	15 22.7	-08 59	.064 ± 8	3	+ 6.54 ± 1	+0.29 ± 2	+ 5.57	8
	- 8°3983 B				3	+ 7.15 ± 1	+0.30 ± 1	+ 6.18	7
3501	-40°9712	15 25.7	-40 54	.167 ± 5	3	+ 8.12 ± 1	+1.05 ± 2	+ 9.24	4
3519*	α CrB AB	15 30.5	+27 03	.043 ± 6	5	+ 2.33 ± 2	-0.11 ± 2	+ 0.50	8
3557*	α Ser A	15 39.3	+06 44	.046 ± 6	4	+ 2.10 ± 1	+0.37 ± 2	+ 0.41	8
	α Ser B				4	+10.88 ± 2	+0.28 ± 4	+ 9.19	10
3569	β Ser A	15 41.6	+15 44	.034 ± 6	7	+ 3.74 ± 2	-0.04 ± 2	+ 1.40	9
	β Ser B				6	+ 9.38 ± 2	+0.33 ± 2	+ 7.04	9
3570*	λ Ser	15 41.6	+07 40	.091 ± 5	6	+ 4.20 ± 1	+0.20 ± 1	+ 4.00	3
3589	β Tri A	15 46.3	-63 07	.078 ± 12	3	+ 2.76 ± 2	+0.07 ± 0	+ 2.22	7
3604	γ Ser	15 51.8	+15 59	.069 ± 7	5	+ 3.67 ± 1	+0.14 ± 3	+ 2.87	7
3669	-57°7690	16 05.7	-57 16	.063 ± 5	2	+ 7.06 ± 1	+0.32 ± 1	+ 6.06	5
3701*	-37°10765	16 13.5	-37 19	.125 ± 7	4	+ 9.34 ± 2	+1.10 ± 2	+ 9.82	5
3712	+67°935 A	16 16.5	+67 29	.088 ± 4	4	+ 7.68 ± 2	+0.68 ± 2	+ 7.40	4
	+67°935 B				4	+ 9.47 ± 1	+1.09 ± 2	+ 9.19	4
3719*	ζ Tr A	16 17.7	-69 52	.083 ± 9	2	+ 4.64 ± 1	+0.18 ± 1	+ 4.24	6
3733	20 C 986	16 21.1	+48 36	.129 ± 10	3	+ 9.05 ± 2	+1.01 ± 3	+ 9.60	6
3746*	-12°4523	16 24.7	-12 25	.244 ± 6	4	+ 8.71 ± 3	+1.20 ± 1	+10.65	2
3773	12 Oph	16 31.1	-02 07	.087 ± 5	3	+ 5.43 ± 2	+0.26 ± 2	+ 5.13	5
3799*	ζ Her	16 37.5	+31 47	.110 ± 4	3	+ 2.56 ± 2	+0.23 ± 1	+ 2.76	3
3815	+33°2777	16 41.4	+33 41	.118 ± 7	3	+ 7.29 ± 2	+0.57 ± 2	+ 7.65	5
3845*	- 8°4352 AB	16 50.1	-08 09	.155 ± 3†	6	+ 7.78 ± 3	+1.08 ± 2	+ 8.74	3
3844*	- 8°4352 C	16 50.1	-08 08		6	+10.35 ± 4	+1.22 ± 5	+11.31	5
3878*	- 4°4225 A	16 59.8	-04 54	.088 ± 4†	4	+ 7.04 ± 1	+0.49 ± 1	+ 6.76	3
3880*	- 4°4226 B	17 00.0	-04 55		4	+ 8.99 ± 2	+0.91 ± 2	+ 8.71	4
3884	-60°6718	17 01.2	-60 37	.079 ± 7	3	+ 7.00 ± 4	+0.34 ± 1	+ 6.49	6
3889	Ross 863	17 02.9	+21 41	.100 ± 12	3	+10.46 ± 2	+1.10 ± 1	+10.46	7
3907*	+45°2505	17 09.2	+45 50	.144 ± 7	4	+ 8.14 ± 2	+1.08 ± 1	+ 8.93	3
3908*	36 Oph AB	17 09.2	-26 27	.175 ± 6†	7	+ 3.94 ± 2	+0.31 ± 1	+ 5.16	2
3913	36 Oph C	17 10.1	-26 24		3	+ 5.67 ± 1	+0.44 ± 1	+ 6.89	3
3919*	HR 6416 AB	17 11.5	-46 32	.125 ± 7	7	+ 5.08 ± 3	+0.32 ± 1	+ 5.56	3
3924*	HR 6426 AB	17 12.1	-34 53	.137 ± 5	7	+ 5.34 ± 2	+0.43 ± 1	+ 6.02	3
	HR 6426 C				3	+ 9.26 ± 6	+0.96 ± 2	+ 9.94	5
3955	+ 2°3312	17 20.8	+02 14	.125 ± 6	3	+ 6.67 ± 3	+0.60 ± 2	+ 7.15	5
3958	-46°11540	17 21.1	-46 47	.213 ± 5	4	+ 8.11 ± 2	+1.03 ± 1	+ 9.75	2
4000	α Oph	17 30.3	+12 38	.056 ± 5	4	+ 2.10 ± 1	0.00 ± 2	+ 0.84	6
4009	18 C 2347	17 33.4	+18 37	.132 ± 9	3	+ 8.55 ± 1	+0.88 ± 1	+ 9.15	4
4029*	+68°946	17 37.0	+68 26	.203 ± 4	4	+ 7.90 ± 2	+1.10 ± 1	+ 9.44	2
4042	β Oph	17 38.5	+04 37	.023 ± 5	4	+ 2.24 ± 1	+0.39 ± 1	- 0.95	10
4053	+43°2796	17 40.9	+43 26	.100 ± 8	3	+ 9.25 ± 3	+1.01 ± 1	+ 9.25	5
4060*	μ Her A	17 42.5	+27 47	.119 ± 5	8	+ 3.12 ± 2	+0.24 ± 1	+ 3.50	1
	μ Her BC				4	+ 8.45 ± 2	+1.10 ± 1	+ 8.83	2
4065	γ Oph	17 42.9	+02 45	.032 ± 5	5	+ 3.84 ± 1	-0.09 ± 1	+ 1.37	8
4098*	+ 4°3561	17 52.9	+04 25	.545 ± 3	3	+ 8.09 ± 1	+1.23 ± 2	+11.77	2
4133	- 3°4233	17 59.8	-03 02	.133 ± 6	4	+ 8.34 ± 2	+0.88 ± 1	+ 8.96	3
4137*	70 Oph AB	18 00.4	+02 31	.188 ± 4	4	+ 3.58 ± 1	+0.30 ± 1	+ 4.95	2
4171*	+38°3095	18 06.3	+38 27	0.092 ± 6	3	+ 5.96 ± 1	+0.34 ± 1	+ 5.78	4

TABLE II. (continued)

Yale No.	Name	α(1900)	δ(1900)	π ± p.e.	n	R ± a.d.	(R-I) ± a.d.	M_R	e
		h m	° '	"		m	m	m	
4245*	χ Dra	18 22.9	+72 41	0.″120 ± 5	4	+ 3.36 ± 2	+0.20 ± 1	+ 3.76	3
4293	α Lyr	18 33.6	+38 41	.123 ± 5	3	+ 0.15 ± 2	-0.09 ± 2	+ 0.59	4
4330	+59°1915 A	18 41.7	+59 29	.280 ± 4	5	+ 7.68 ± 2	+1.07 ± 2	+ 9.92	3
	+59°1915 B				5	+ 8.38 ± 2	+1.14 ± 2	+10.62	3
4338*	Ross 154	18 43.6	-23 57	.351 ± 6	3	+ 9.43 ± 2	+1.30 ± 2	+12.16	3
4436*	ζ Aql	19 00.8	+13 43	.036 ± 7	5	+ 3.10 ± 1	-0.07 ± 2	+ 0.88	10
4451*	Ross 730 B	19 02.8	+20 44	.116 ± 6	3	+ 9.62 ± 1	+0.95 ± 1	+ 9.94	4
	Ross 731 A				3	+ 9.61 ± 1	+0.96 ± 1	+ 9.93	4
4459*	20 C 1130	19 03.6	+32 21	.123 ± 4	5	+ 9.92 ± 3	+1.16 ± 3	+10.36	4
4494*	Wolf 1055	19 12.1	+05 03	.168 ± 4	5	+ 7.90 ± 1	+1.00 ± 2	+ 9.03	3
4607*	σ Dra	19 32.6	+69 29	.174 ± 4	3	+ 4.32 ± 2	+0.29 ± 1	+ 5.52	2
4646	20 C 1163	19 41.7	+26 55	.097 ± 6	4	+10.92 ± 3	+1.30 ± 3	+10.85	6
4665	α Aql	19 45.9	+08 36	.198 ± 4	4	+ 0.76 ± 1	+0.02 ± 1	+ 2.24	2
4705*	β Aql	19 50.4	+06 09	.070 ± 3	3	+ 3.35 ± 2	+0.31 ± 1	+ 2.58	3
4754	δ Pav	19 58.9	-66 26	.170 ± 7	3	+ 3.24 ± 1	+0.23 ± 1	+ 4.39	3
4775*	20 C 1191	20 02.8	+54 10	.059 ± 6	6	+10.96 ± 1	+0.84 ± 3	+ 9.82	7
4782*	HR 7703	20 04.6	-36 21	.174 ± 10	3	+ 4.90 ± 1	+0.34 ± 1	+ 6.10	4
4794	-45°13677	20 06.7	-45 28	.158 ± 6	3	+ 7.02 ± 1	+0.73 ± 1	+ 8.01	3
4804*	HR 7722	20 09.1	-27 20	.116 ± 7	3	+ 5.34 ± 1	+0.31 ± 1	+ 5.66	4
4889*	20 C 1213	20 29.0	+65 06	.124 ± 5	3	+ 9.28 ± 1	+1.07 ± 1	+ 9.74	3
4924	-53°9928	20 35.0	-53 02	.080 ± 6	3	+ 8.02 ± 2	+0.61 ± 1	+ 7.54	5
4929*	-32°16135 AB	20 35.6	-32 47	.113 ± 8	4	+ 8.69 ± 1	+1.31 ± 2	+ 8.95	5
4939*	-31°17815	20 38.9	-31 42	.104 ± 7	4	+ 7.52 ± 2	+0.84 ± 1	+ 7.60	4
4947	ψ Cap	20 40.2	-25 38	.090 ± 10	4	+ 3.97 ± 2	+0.14 ± 1	+ 3.74	6
4966*	η Cep	20 43.3	+61 27	.071 ± 4	4	+ 3.02 ± 2	+0.33 ± 2	+ 2.28	5
5012	+61°2068	20 51.3	+61 48	.137 ± 4	3	+ 7.53 ± 2	+0.82 ± 2	+ 8.21	4
5043*	20 C 1250	20 56.2	+39 41	.072 ± 8	3	+ 9.00 ± 1	+0.91 ± 2	+ 8.29	7
5077*	61 Cyg A	21 02.4	+38 15	.293 ± 3	5	+ 4.60 ± 2	+0.47 ± 1	+ 6.94	1
	61 Cyg B				5	+ 5.27 ± 2	+0.60 ± 3	+ 7.61	3
5117	-39°14192	21 11.4	-39 15	.255 ± 8	3	+ 5.78 ± 1	+0.69 ± 1	+ 7.81	3
5139	α Cep	21 16.2	+62 10	.063 ± 5	2	+ 2.44 ± 0	+0.02 ± 1	+ 1.44	5
5152	γ Pav	21 18.2	-65 49	.111 ± 8	3	+ 4.03 ± 3	+0.20 ± 1	+ 4.25	5
5177	20 C 1285	21 24.8	+17 12	.149 ± 5	7	+ 8.95 ± 1	+1.17 ± 2	+ 9.82	3
5184	Wolf 922	21 25.8	-10 14	.122 ± 11	5	+10.43 ± 2	+1.36 ± 2	+10.86	6
5190	-49°13515	21 26.9	-49 26	.209 ± 7	4	+ 7.56 ± 2	+0.93 ± 1	+ 9.16	3
5305	-60°7528	21 52.3	-60 13	.074 ± 7	3	+ 8.70 ± 2	+0.79 ± 2	+ 8.05	7
5314*	ε Ind	21 55.7	-57 12	.285 ± 7	4	+ 4.17 ± 3	+0.40 ± 1	+ 6.45	2
5318	+ 0°4810	21 57.1	+00 56	.102 ± 8	4	+ 8.18 ± 1	+0.76 ± 2	+ 8.22	6
5358	- 5°5715	22 04.4	-05 08	.108 ± 5	5	+ 9.07 ± 3	+1.09 ± 2	+ 9.23	4
5397	Wolf 1561 A	22 12.1	-09 18	.100 ± 12	4	+12.04 ± 5	+1.41 ± 4	+12.04	10
	Wolf 1561 B				4	+12.87 ± 5	+1.66 ± 4	+12.87	10
5432	-30°19175	22 23.6	-30 30	.070 ± 8	3	+ 7.08 ± 2	+0.36 ± 2	+ 6.31	8
5438*	Kr 60 AB	22 24.4	+57 12	.249 ± 4	3	+ 8.17 ± 2	+1.15 ± 2	+10.15	3
5475*	LPM 837	22 33.0	-15 52	.295 ± 5	5	+10.26 ± 2	+1.66 ± 2	+12.61	3
5520*	+43°4305	22 42.5	+43 49	.198 ± 4	3	+ 8.83 ± 3	+1.15 ± 1	+10.31	2
5546	-15°6290	22 47.9	-14 47	.206 ± 6	5	+ 8.76 ± 4	+1.22 ± 1	+10.33	2
5562*	HR 8721	22 50.8	-32 06	.123 ± 8	4	+ 5.91 ± 1	+0.43 ± 2	+ 6.35	5
5563*	+15 4733	22 51.8	+16 02	.150 ± 5	20	+ 7.58 ± 1	+0.88 ± 1	+ 8.46	2
5565	α PsA	22 52.1	-30 09	.144 ± 7	4	+ 1.24 ± 3	-0.06 ± 1	+ 2.03	3
5569*	+ 8°4973 AB	22 53.5	+08 50	.033 ± 5	3	+ 6.19 ± 1	+0.24 ± 1	+ 3.78	8
5572	-23°17699	22 55.0	-23 04	.125 ± 6	4	+ 7.02 ± 2	+0.62 ± 1	+ 7.50	3
5584*	-36°15693	22 59.4	-36 26	.273 ± 7	3	+ 6.31 ± 1	+0.85 ± 1	+ 8.49	3
5587	α Peg	22 59.8	+14 40	.030 ± 5	3	+ 2.63 ± 2	-0.08 ± 1	+ 0.02	9
5616	HR 8832	23 08.5	+56 37	.152 ± 5	3	+ 5.06 ± 1	+0.35 ± 2	+ 5.97	4
5694*	+19°5116 AB	23 26.8	+19 21	0.144 ± 12	3	+ 8.77 ± 2	+1.24 ± 1	+ 9.56	5

TABLE II. (continued)

Yale No.	Name	α(1900)	δ(1900)	π ± p.e.	n	R ± a.d.	(R-I) ± a.d.	M_R	e
		h m				m	m	m	
5721	-73°2299	23 33.7	-73°15′	0.″102 ± 8	3	+ 6.57 ± 1	+0.39 ± 1	+ 6.61	5
5724	ι Psc	23 34.8	+05 05	.064 ± 7	4	+ 3.94 ± 1	+0.19 ± 1	+ 2.97	6
5725*	γ Cep	23 35.2	+77 04	.064 ± 5	4	+ 2.79 ± 1	+0.34 ± 2	+ 1.82	6
5736*	Ross 248	23 37.0	+43 39	.316 ± 5	8	+10.41 ± 4	+1.56 ± 4	+12.91	4
5763*	+ 1°4774	23 44.0	+01 52	.162 ± 6	5	+ 7.95 ± 2	+0.87 ± 1	+ 9.00	3
5772*	+74°1047 AB	23 47.5	+74 59	.090 ± 4	3	+ 5.87 ± 2	+0.38 ± 1	+ 5.64	3
5817*	-37°15492	23 59.5	-37 51	0.219 ± 8	3	+ 7.49 ± 2	+0.92 ± 1	+ 9.19	3

NOTES TO TABLE II

No.

49 ADS 246. Joy finds component A is a spectroscopic binary (SB); component B has subdwarf spectrum.

69 $T = 71$ km/sec; $V = +23$ km/sec.

155 ADS 671. Component A is unresolved astrometric binary (AsB).

177 Joy finds SB.

219 $T = 131$ km/sec; $V = -97$ km/sec.

328 Additional π available; Cape, *M. N.* **112**, 92, 1952.

L726–8 Not in Yale Catalog. Parallax from van de Kamp and Lippincott, *Pub. A. S. P.* **62**, 47, 1950. Flare star, UV Cet visual binary (VsB).

352 VsB, equal mags.

394 SB, one spectrum.

450 $T = 134$ km/sec; $V = +7$ km/sec.

520 $T = 174$ km/sec; $V = +23.4$ km/sec.

549 ADS 2081. Fainter companion, 10 mag. at 18″, of negligible brightness.

647 $T = 72$ km/sec; $V = +50$ km/sec.

664 ADS 2402. Fainter companion, 7.0 mag. at 0″.9, will make system about 0.07 mag. brighter than brighter component.

703 $T = 96$ km/sec; $V = +86.8$ km/sec.

754 $T = 26$ km/sec; $V = +65$ km/sec.

873 ADS 2894. Fainter companion, 12.0 mag. at 11″, will cause system to be about 0.05 mag. brighter than brighter component. The brightness of the M4 companion in the infrared, however, will probably seriously affect the *R-I* color. It will be possible to measure individually the components of this system.

945 ADS 3093 A, BC. The close pair BC, white and red dwarf, will be measurable separately. $T = 96$ km/sec; $V = -42$ km/sec.

1129 SB. $T = 56$ km/sec; $V = +27$ km/sec.

1135 Additional π available; Cape, *M. N.* **112**, 92, 1952.

1181 $T = 164$ km/sec; $V = +242$ km/sec; Kapteyn's star.

1187 ADS 3841. Close VsB of almost equal mag.

1193 Common μ with 1187, here regarded as part of the α Aur system. The two components, at 2″, differ by 3.7 mag.

1199 $T = 61$ km/sec; $V = +65.7$ km/sec.

1279 SB, one spectrum, complications from secondary oscillations in V.

1301 ADS 4263. Composite mag. and color will be influenced by companion.

1305 Additional π available; Sproul, *A. J.* 1206. $T = 77$ km/sec; $V = +103$ km/sec. Has subdwarf spectrum.

1341 $T = 144$ km/sec; $V = +25$ km/sec.

1509 Unresolved AsB.

1538 $T = 41$ km/sec; $V = -59$ km/sec.

1539 Unresolved AsB.

1577 ADS 5423. Companion of negligible brightness.

1609 Additional π available; Sproul, *A. J.* 1192.

No.

1668 Joy finds SB.

1708 ADS 5961. Companion, 10 mag. at 10″, has no appreciable effect on mag. or *R-I*.

1718 ADS 5983. Companion, 8 mag. at 7″, will make system about 0.02 mag. brighter and 0.01 mag. bluer than principal star.

1755 $T = 68$ km/sec; $V = +26$ km/sec; Luyten's star.

1774 Additional π available; Yerkes, *A. J.* 1192. Joy finds A is SB.

1785 SB and eclipsing variable with equal components. Member of complex α Gem system.

1805 Additional π available; Yerkes, *A. J.* 1192. Light of companion negligible.

1809 Additional π available; Cape, *M. N.* **112**, 92, 1952.

1827 Additional π available; Yerkes, *A. J.* 1192. Flare star YZ CMi.

1942 $T = 169$ km/sec; $V = -35$ km/sec.

2098 Complex system; brightest companion measured along with principal. Mag. will be about 0.02 mag. brighter and 0.01 mag. redder than principal.

2113 ADS 7067. Components, at 4″, almost equal mag.

2267 Additional π available; Yerkes, *A. J.* 1192. Unresolved AsB.

2280 ADS 7441. Companion, 14 mag. at 4″, negligible.

2313 $T = 37$ km/sec; $V = +60$ km/sec.

2379 VsB 1″, almost equal mags.

2384 α Leo BC; companion of α Leo, VsB 3″. Mag. and color are practically those of component B.

2420 Additional π available; Van Vleck, *A. J.* 1191. Unresolved AsB. Flare star AD Leo.

2524 Joy finds SB.

2553 Additional π available; Sproul, *A. J.* 1206.

2576 $T = 55$ km/sec; $V = -86$ km/sec. Unresolved AsB.

2582 $T = 124$ km/sec; $V = +64$ km/sec; fainter component is flare star WX UMa. The large a.d. of R may indicate variation of this star.

2631 $T = 125$ km/sec; $V = +46.9$ km/sec.

2722 $T = 21$ km/sec; $V = -115$ km/sec.

2730 Additional π available; Sproul, *A. J.* 1206.

2745 $T = 288$ km/sec; $V = -98.3$ km/sec.

2857 $T = 120$ km/sec; $V = +58$ km/sec.

2890 VsB equal components.

2935 $T = 28$ km/sec; $V = +80.9$ km/sec.

2951 Additional π available; Cape, *M. N.* **112**, 92, 1952.

3063 Additional π available; Cape, *M. N.* **112**, 92, 1952; SB.

3074 VsB, components differ by 2.8 mag.

3135 Additional π available; Sproul, *A. J.* 1192.

3175 SB.

3273 $T = 126$ km/sec; $V = +5$ km/sec.

3278 The flare star V645 (Proxima) Cen.

3360 ADS 3914.

No.	
3425	T = 436 km/sec; V = +302 km/sec.
3519	Eclipsing binary. Fainter component makes system 0.02 mag. brighter than brighter component.
3557	Optical double.
3570	T = 12 km/sec; V = −66.4 km/sec.
3701	LPM 597, VsB; companion makes system significantly brighter and redder than principal.
3719	SB.
3746	SB.
3799	ADS 10157. T = 28 km/sec; V = −69.9 km/sec. Light from companion insignificant.
3844	SB.
3845	VsB, equal components. Common μ with 3844.
3878, 80	T = 77.5 km/sec; V = +28 km/sec.
3907	VsB. Light from companion significant.
3908	ADS 10417, components of equal magnitude. Common μ with 3913.
3919	VsB. Light from companion significant.
3924	Triple star, AB unresolvable, light from companion significant.
4029	Van de Kamp suspects AsB.
4060	Triple star, BC unresolvable, light from companion significant. Additional π available; Allegheny, *A. J.* 1195.
4098	Barnard's star, AsB. T = 90 km/sec; V = −108 km/sec.
4137	ADS 11046. Light from companion significant.
4171	Additional π available; Allegheny, *A. J.* 1195.
4245	SB and AsB.
4338	Flare star V 1216 Sgr.
4436	ADS 12026. Light from companion negligible.
4451	Additional π available; Yerkes, *A. J.* 1192.
4459	ADS 12061C, an optical companion with 17 Lyr; No. 4459 is a VsB, with significant light from companion. T = 64 km/sec; V = −31 km/sec.
4494	The bright companion of van Biesbroeck's star.
4607	Additional π available; Sproul, *A. J.* 1192.
4705	ADS 13110. Companion negligible. Additional π available; Allegheny, *A. J.* 1195.
4775	SB. T = 131 km/sec; V = 0 km/sec.
4782	VsB. Light from companion negligible. T = 47 km/sec; V = −131.2 km/sec.
4804	T = 51 km/sec; V = −55 km/sec.
4889	Suspected AsB.
4929	VsB, almost equal components. Common μ with 4939?
4939	Joy finds variable V of small amplitude.
4966	T = 55 km/sec; V = −87.3 km/sec.
5043	VsB. Light from companion significant.
5077	Additional π available; Sproul, *A. J.* 1205. T = 85 km/sec; V = −64 km/sec.
5314	T = 78 km/sec; V = −40.4 km/sec.
5438	ADS 15972. Light from companion significant. Additional π available; Yerkes, *A. J.* 1198.
5475	Additional π available; Sproul, *A. J.* 1206. T = 55 km/sec; V = −60 km/sec.
5520	Flare star.
5562	Common μ with 5565. Mean π = 0.″130 ±0.″006.
5563	SB.
5569	ADS 16417. Light from companion significant. Eggen finds variable.
5584	T = 120 km/sec; V = +9.7 km/sec.
5694	VsB. Light from companion significant.
5725	Has subgiant spectral characteristics.
5736	T = 28 km/sec; V = −81 km/sec. Joy finds probably subdwarf.
5763	Additional π; Sproul, *A. J.* 1206. T = 41 km/sec; V = −64 km/sec.
5772	ADS 17062. Companion affects combined light by 0.01 mag., but brighter component itself is SB.
5817	T = 132 km/sec; V = +23.6 km/sec.

gives figures of estimated uncertainty, e, intended to express the suitability of the data to define a locus in a color-magnitude diagram, and to provide a basis for dividing the data into categories of lesser and greater precision. They were computed from the following equation, which combines into one number in a simple, empirical manner the tabulated errors in the red magnitude, the R-I color index, and the parallax. The formula is admittedly arbitrary, but it is useful here, and its simplicity recommends it over a more rigorous but needlessly complex expression, such as might be derived from the theory of the propagation of errors.

$$e = 200\left\{\frac{1/n(\text{a.d. of } R) + (\text{p.e. of Modulus})}{10} + 1/n(\text{a.d. of } R\text{-}I)\right\}.$$

In this equation, the factor 10 is the approximate mean slope of the color-magnitude locus. The p.e. of the modulus is derived from the parallax and its p.e. The coefficient 200 is a normalizing factor to produce integral values of e. Other entries in the equation come from obvious sources. If e is 3 or smaller, the star is highly suitable for testing a color-magnitude relation. As e increases, the suitability of the star becomes less. The behavior of e can be noted from the following examples. The star α Eridani (No. 344) has been observed with excellent photometric precision, but it has a low-precision parallax; the value for e is 24, too large for use in a good color-magnitude array. Ross 594 (No. 992) has moderately inferior data for all quantities; e is 11, a poor value. The influence of an inaccurate magnitude alone is not well shown by our data, as there is no outstanding example, and e is not very sensitive to errors in red magnitude R. The value for e is sensitive to the color, however, and an example of the influence of color precision is given by the visual binary γ Virginis (No. 2924). Component A has a well-determined color, B does not, and the respective values of e are 4 and 7, good and fair. Generally, e is most sensitive to errors in the parallax, which is usually the most difficult quantity to obtain with precision.

The star BD +57°1266 has common proper motion with No. 2457 and No. 2459. It has been considered to be a member of a triple system (Eggen 1950). Johnson and Morgan (1953), however, indicate that the spectrum of this star has subgiant characteristics; this would rule out membership in the system, and require that the common proper motion characteristic be fortuitous. No trigonometric parallax is available for this star, but because of its interesting nature the color and magnitude are recorded here, outside of Table II:

BD $+57°1266$, $R = 7.81 \pm .02$ mag.;
$R\text{-}I = +0.32 \pm .02$ mag.; $n = 4$.

The star Ross 154 (No. 4338) probably was undergoing a flare on the first night it was observed in Australia, July 1, 1951. On this night the star was so bright visually that a wrong, brighter star was observed on July 28, the next night that photometry was done. By July 29, with the July 1 and July 28 data reduced and available, it became apparent that something was wrong. Thus several stars in the field were observed, the star observed July 28 was identified, as was the red dwarf, which was then reobserved on August 12 and August 27. On July 1, Ross 154 was 0.42 mag. brighter and 0.07 mag. bluer than the mean of the other three nights. It is interesting to note that this is the first red dwarf that has had its color recorded during a flare, and it may be significant that the color was found to be bluer than normal.

In the Notes to Table II an attempt has been made to supply general information concerning the stars in the table. The Yale catalogue was used as the principal source of identification of visual double stars and astrometric binaries. Spectroscopic binaries were identified from the radial velocity data of Joy (1947) and of Joy and Mitchell (1948). For stars that had rather high radial velocities or tangential motions, we computed tangential velocities from the proper motion and parallax data in the Yale catalogue, and used radial velocities by Joy, or by Joy and Mitchell, and, when it became available, from the *General Catalogue of Stellar Radial Velocities* (Wilson 1953). The Notes also designate all stars that have been known to flare.

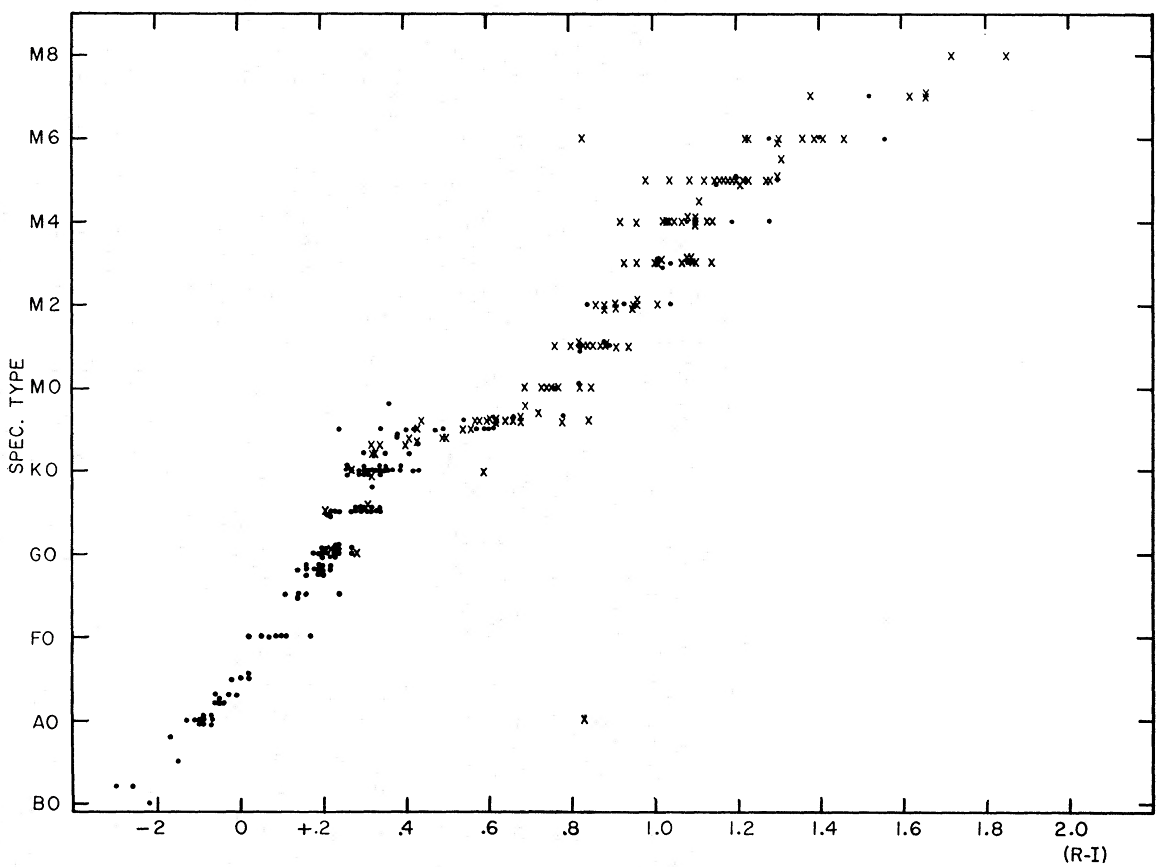

Figure 1. Relationship between $R\text{-}I$ color and spectral type taken from the Yale *General Catalogue of Trigonometric Stellar Parallaxes*. Crosses represent spectral types by Kuiper, dots spectral types from other sources.

Discussion. Figure 1 is a plot of the *R-I* colors vs. the spectral type as given in the Yale catalogue. Solid points represent HD types; crosses, spectral types by Kuiper. The discontinuity at type K5 and $R\text{-}I \sim 0.4$ to 0.7 mag. is interesting but probably of little significance, as it may simply indicate that the scale change in spectral type should have taken place at K4 instead of at M0. The effect of binary nature is shown in an exaggerated way by the plot of o^2 Eri BC, at the integrated color $R\text{-}I = +0.83$ mag. and either at A0 if the pair were the white dwarf, or at M6 if the pair were the red dwarf. It may be possible to discover by this method binary systems that resist identification by other methods. For example, No. 2857 M5 at $R\text{-}I = +0.98$ mag. could be somewhat discordant because of a blue companion of low luminosity. Also, α Cen B (No. 3309) seems discordant on the basis of the HD spectral type of K5; however, revised types, such as the ones given in the *Fifth Catalogue of the Orbital Elements of Spectroscopic Binary Stars* (Moore and Neubauer 1948), make this star of somewhat earlier type, about K1. If so, α Cen B is not badly discordant, but if component B actually is a K5 star, there may be some possibility that it is a binary. In general, Figure 1 shows a fairly satisfactory correlation between spectral type and color on the *R-I* system, and displays the properties of this particular red color system.

In Figure 2, the absolute red magnitude has been plotted against the *R-I* color, with all data in Table II included. The large symbols represent stars with $e \leqslant 3$, whereas the small symbols represent stars with $e \geqslant 4$, so that the data are approximately segregated according to accuracy. Flagged symbols indicate that the star has emission lines in its spectrum, according to the *Cata-*

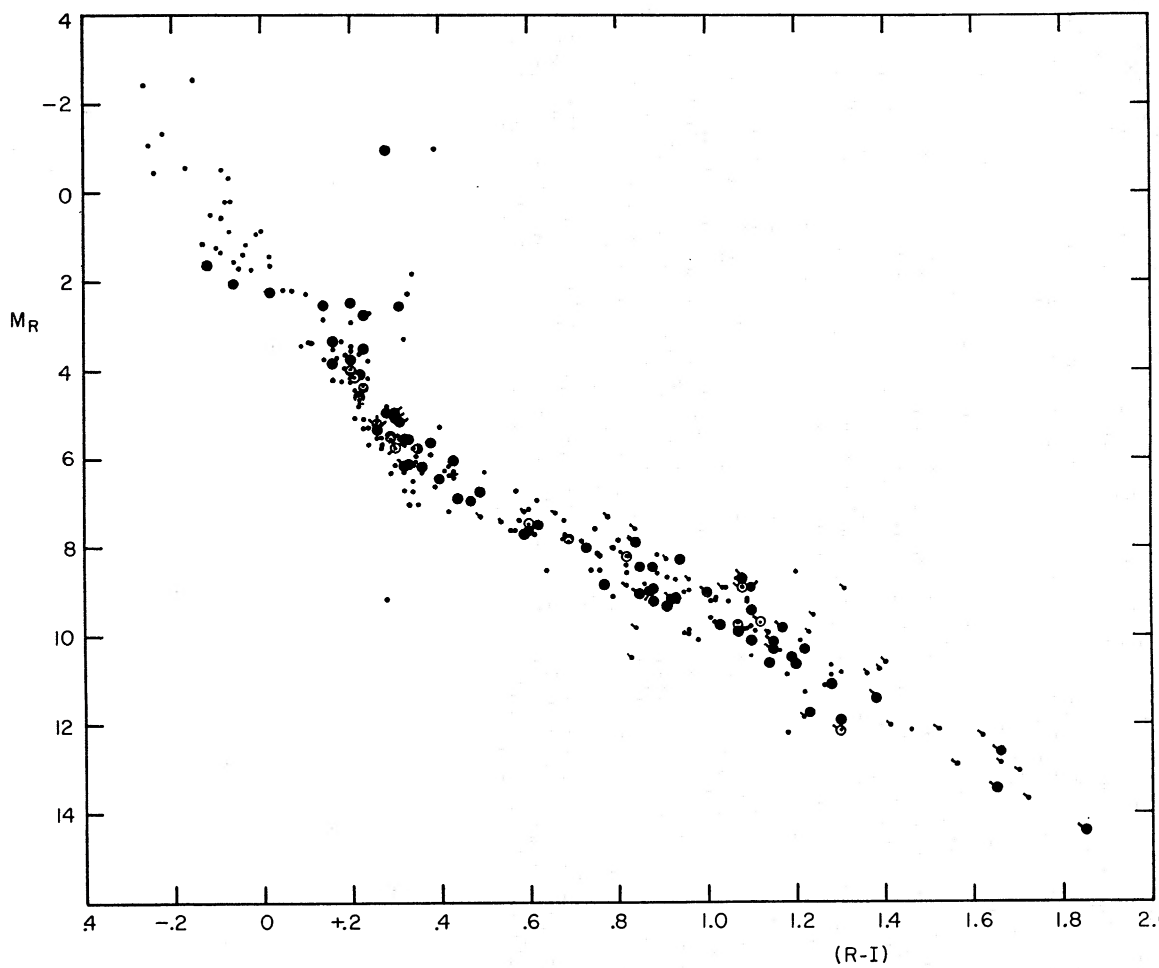

Figure 2. Plot of absolute red magnitude M_R vs. *R-I* color for all 282 stars in Table II. Large symbols, $e \leq 3$; small symbols, $e \geq 4$. Stars represented by flagged symbols have emission lines in their spectra.

logue and Bibliography of Emission-Line Stars of Types Later than B (Bidelman 1954).

In Figure 2, the two giants α Aurigae and β Ophiuchi stand out at $M_R = -1$ mag. Considerable scatter is apparent among the A-type main sequence stars, which plot from $M_R = -0.5$ to $+2$ mag. and $R\text{-}I = -0.13$ to $+0.02$ mag.; much of this scatter must arise because many of the parallaxes for A-type stars are small. However, the difference of 1.44 mag. in luminosity between the two large-parallax stars αPsA (No. 5565) and α Lyr (No. 4293) confirms that large differences of luminosity can occur among dwarf A-type stars of nearly equal color (c.f. Eggen, 1950, p. 151). The subgiants are of absolute magnitude about $+2.5$, and they plot from $R\text{-}I = +0.14$ to $+0.34$ mag. The most conspicuous part of the main sequence starts at $M_R \sim +3.3$ and $R\text{-}I \sim +0.18$ mag. and sweeps down and to the right to the reddest and faintest star observed on the program, Wolf 359 (No. 2553). Considerable scatter seems apparent here, too, even among the points having higher accuracy. However, some of the spread among the red dwarfs is due to a bifurcation in the diagram, as reported by one of us (Kron 1954). Indications of this result may be seen in this diagram, despite inclusion of data for known double stars. The flagged points show that emission-line stars are more abundant among the very late types (Kuiper 1942; Joy 1947), or at least that emission characteristics are more easily seen in spectra of these stars. The presence of emission lines in the spectra of M dwarfs evidently does not seriously affect the absolute red magnitude of the star, which strengthens a previous conclusion that emission-line radiation in a red dwarf probably is a superficial characteristic (Kron 1950). Flares also seem to be a superficial phenomenon, since the known flare stars lie normally in the diagram. If most red dwarfs exhibit flare characteristics at some time, then, as time goes on, a higher percentage of them will be classified as flare-stars, since the probability that this rare event will be observed in any given star increases with time.

Figure 3 is a replot of some of the data of Figure 2, with omission of giants, spectroscopic binaries, visual binaries that are photometrically unresolved, i.e. primary light affected by that of a secondary, and all observations with $e > 5$. In addition, the plotted points have been segregated according to space velocity. For the points indicated by dots, the space velocity is unknown or less than 70 km/sec; for the triangles it is greater than 70 km/sec. It is clear that the scatter is much less in Figure 3 than in Figure 2. In addition, it can be seen that there are systematic differences that depend upon space velocity.

These velocity differences, which are small but unmistakable, can be seen better in Figure 4. Here the dots represent group means, each computed by averaging M_R and $R\text{-}I$ for six successive low-velocity points plotted in Figure 3, except for the dots at $R\text{-}I = +1.1$ and $+1.26$ mag., which have seven points, and that at $+1.7$ mag., which has only four points. Through these means we have drawn a smooth curve, which is intended as a first approximation, in this color system, to the main sequence of the color absolute magnitude diagram for these nearby low-velocity dwarfs. The six open circles are for low-velocity stars so discordant that they were not included in the means. The triangles, however, represent all single stars in Table II that have a space velocity greater than 70 km/sec. Figure 4 suggests strongly that high-velocity stars redder than $R\text{-}I = +0.40$ mag. lie below the drawn-line main sequence, whereas high-velocity stars bluer than $R\text{-}I = +0.25$ mag. lie above it. Thus the high-velocity stars may form a sequence of their own that crosses the main sequence at about $+0.30$ mag., and the crossover occurs at about spectral type G4, where Eggen (1950) found that his "subdwarf" sequence crossed the main sequence. Many of those stars are included with the high-velocity stars plotted in Figures 3 and 4 as triangles. To the extent that these points depart systematically from the others, the present observations support the concept of a separate dwarf sequence, for which Eggen also had noted the property of its being composed mainly of stars of higher velocity.

The dispersion inherent in the color-luminosity properties of these nearby stars may be seen better in Figure 5. Here, the main sequence is drawn as in Figure 4, but we have plotted only those low-velocity dwarf stars with $e \leq 3$. Known spectroscopic binaries and photometrically unresolved visual binaries are plotted as open circles; three photometrically unresolved visual binaries (Nos. 352, 1187, 3908) known to have equal components have been plotted as single dots 0.75 mag. lower than the measured magnitude. For the 49 plotted points representing stars believed to be single, the sum of the luminosity residuals from the curve is $\sum|\Delta M_R| = 14.70$ mag., which gives an a.d. $= 0.30$ mag. This is an upper limit for the mean scatter inherent in these nearby stars, for this number includes

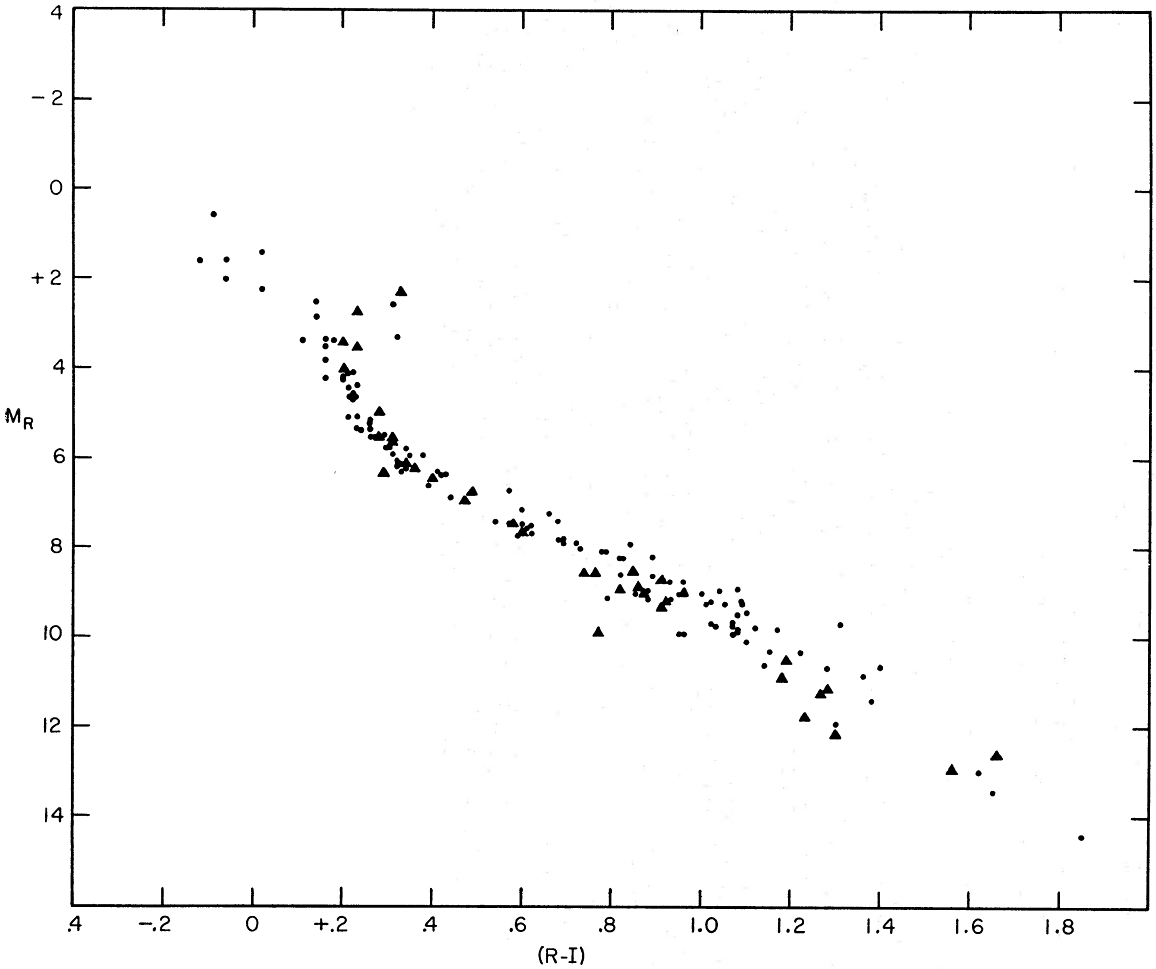

Figure 3. Plot of absolute red magnitude M_R vs. *R-I* for stars in Table II of luminosity classes IV and V with $e \leq 4$, that are believed to be single. Round symbols represent stars with space velocity less than 70 km/sec, triangular symbols represent stars with space velocity greater than 70 km/sec. Five stars with unmeasured radial velocity are plotted with round symbols.

all observational errors. Star No. 4338 at $R\text{-}I = +1.3$ mag. has the largest negative residual, -1.2 mag., and although it is not a high space velocity object according to the definition adopted here, it may belong to the other sequence. In addition, a few of the stars considered single may in fact be double; if such objects were omitted from Figure 5, it is reasonable to expect that the scatter would be smaller.

The scatter among the A-type stars is considerable. On the other hand, the scatter from $R\text{-}I = +0.18$ to $R\text{-}I = +0.80$ mag. (from F5 to M0) appears smaller than in other parts of the diagram. In fact, if the smooth curve were replaced by three lines joining successively at $R\text{-}I = +0.18$ and at $R\text{-}I + = 0.32$ mag., the scatter among stars in this color range would be within observational error. Redward from $R\text{-}I = +0.80$ mag. the scatter seems to increase rather suddenly, and it remains high to the lower end of the diagram. We conclude, therefore, that the present data indicate considerable inherent scatter in the color-absolute magnitude diagram for these nearby stars whose *R-I* colors are less than $+0.18$ and greater than $+0.80$ mag., but that there is little or no evidence that stars from F5 to M0, which lie between these two limits, have significant scatter. Unfortunately, there is not much hope for a more comprehensive study of this kind, since the present sample of nearby stars with accurate parallaxes is practically complete.

The two lists of stars recently published by Eggen (1955), with magnitudes and colors on his ultraviolet-free *P*, *V* system, have 131 dwarf stars in common with the present list. In Figure 6

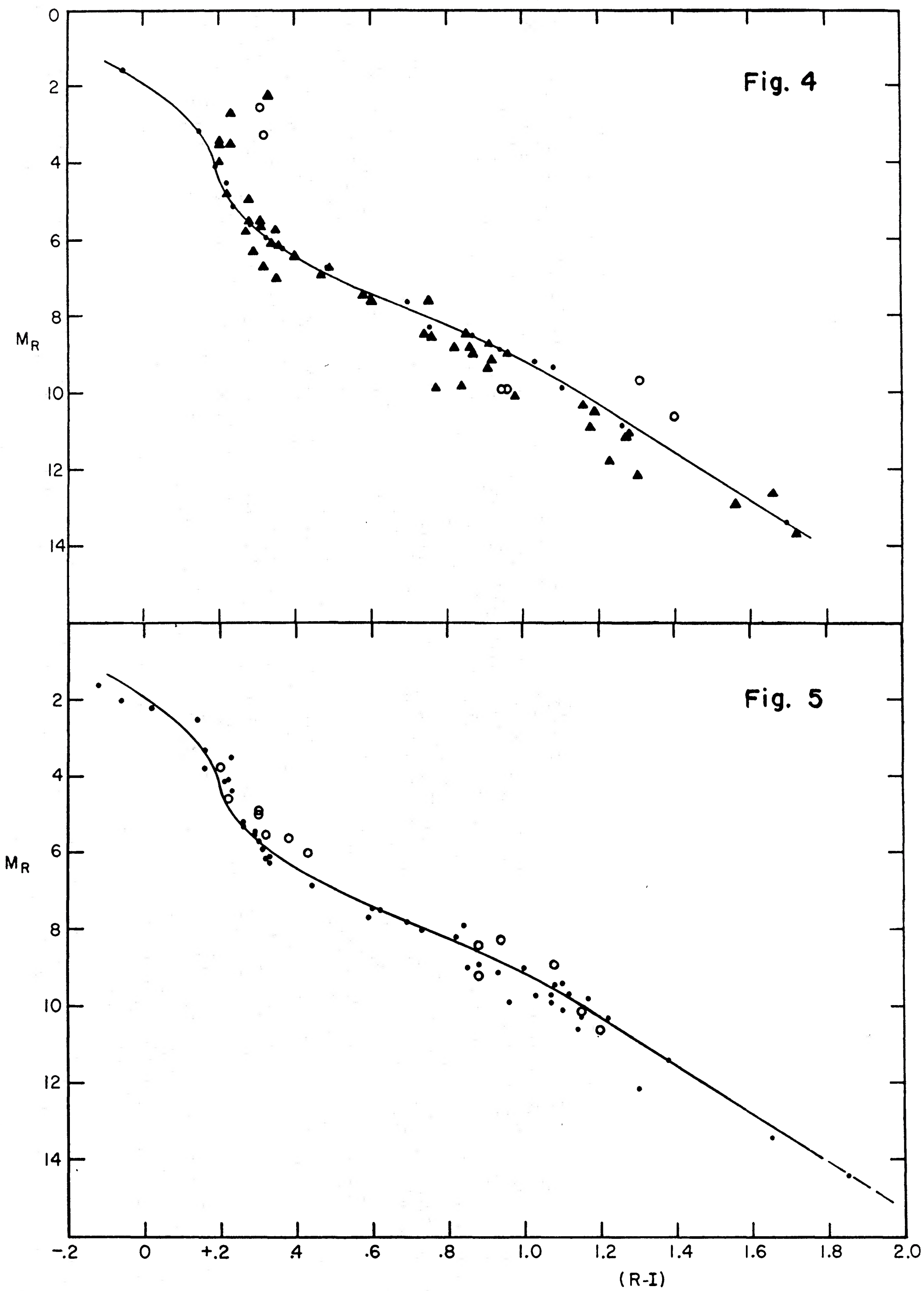

Figure 4. Like Figure 3, but locus of main sequence drawn through dots, which are group means computed as explained in the text. Open circles represent points not included in the means.

Figure 5. Round symbols represent single stars with low velocity and $e \leq 3$, plotted along with mean main-sequence locus as in Figure 4, to show dispersion. Open circles represent known binaries that are photometrically unresolvable.

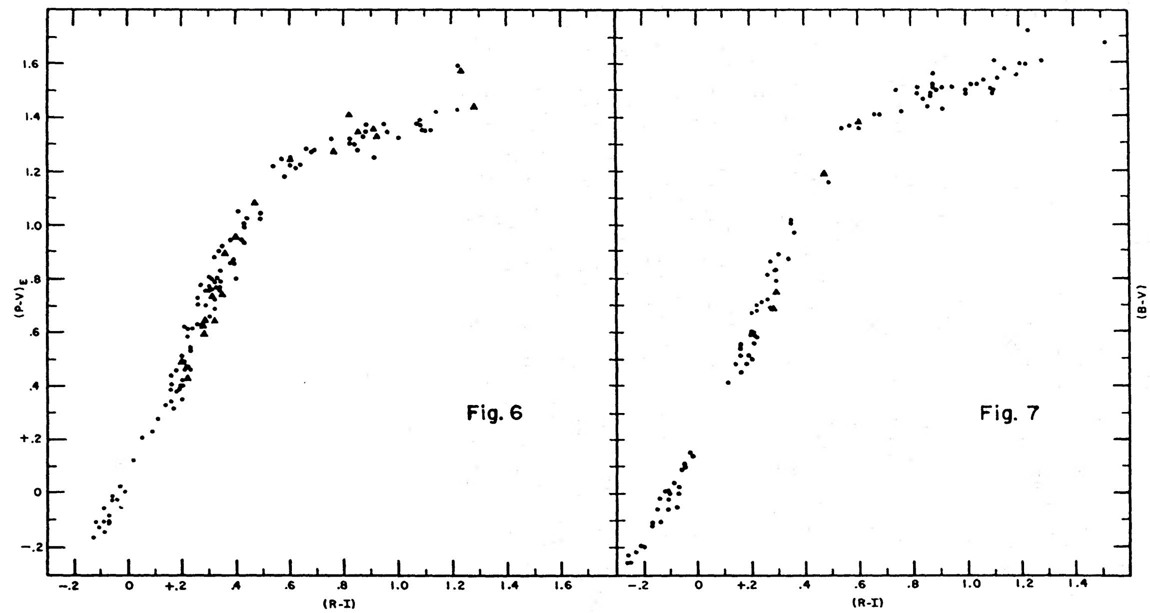

Figure 6. Comparison of R-I color system with the $(P\text{-}V)_E$ system of Eggen.

Figure 7. Comparison of the R-I color system with the B-V system of H. L. Johnson.

we have plotted Eggen's colors, $(P\text{-}V)_E$, against R-I. The high slope from the blue end up to R-I = +0.6 mag. is caused by the smaller wavelength difference of the R-I system as compared with the $(P\text{-}V)_E$ system. Two stars classified traditionally as subdwarfs, 49B and 4098 (Barnard's star) stand out at the top. Another feature of the diagram is the large scatter beginning at R-I = +0.16 mag. and extending redwards from this point, almost exactly where the small cosmic scatter in R-I begins. For colors bluer than R-I = +0.16 mag., the scatter is about that to be expected from the combined observational error of the two sets of data. The scatter to the redward of +0.16, however, is five to ten times greater than expected from the internal precision of the two sets of data. In order to study this result more closely, data for 98 dwarf stars in common with the R, I system and the B, V system of Johnson and Morgan (1953) and of Johnson and Harris (1954) have been plotted in Figure 7. There are bluer stars here than in Figure 6, and there may be a second region of larger scatter around R-I = −0.10 mag. Otherwise, the two plots look much alike.

Any abnormal scatter cannot reasonably be ascribed to inhomogeneity in luminosity class, because of the careful selection of stars in this respect. It can hardly be due to the influence of unsuspected stellar companions, or by space reddening. We therefore briefly consider two other possibilities, that the scatter comes either (1) from systematic observational errors that are larger than we suspect, or (2) from a genuine failure of colors on two independent and widely differing color systems to correlate closely. The relatively small scatter among the bluer stars encourages us to believe that the systematic errors are no larger, or at least not much larger, than the errors of measurement. By this elimination, we are led to examine in detail possibility (2).

By now the effects on stellar colorimetry of sharp discontinuities in the stellar spectral-energy distribution are well known, chiefly as the result of experience with the major phenomenon of this type, the Balmer discontinuity. Stellar spectral-energy curves, however, contain features of similar nature, but of less prominence than the Balmer discontinuity. To produce an abnormal scatter in a comparison of two different color systems, it is only necessary to postulate sufficient variation in the chemical composition of the photospheres of different stars to cause distortions in the spectral-energy curve that would affect colors in one region of the spectrum more than those in another. Furthermore, there is no reason why such effects need necessarily be a function of luminosity alone. Hence, to this extent, scatter in a color-absolute magnitude diagram may be observational, dependent upon the particular color system used. For example, the scatter to the redwards of R-I = +0.80 mag. in Figure 5 may be caused by variations in TiO band intensity; thus it may not represent a real scatter in luminosity, but rather one in the measured colors.

If the foregoing conclusions are correct, and if they hold for stars in the F5-M0 spectral range, then colors must be used with more caution than has been employed in the past, until we know more about spectral features similar to but less obvious than the Balmer discontinuity. Some of the effects shown by the colors of stars in clusters, for example, may be attributable only partly to space reddening. Thus the practice of shifting color-magnitude diagrams of clusters into coincidence, especially for clusters containing population stars for which spectrophotometric data are scarce at the present time, may introduce systematic errors appreciably larger than expected from the photometric precision.

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Lick Observatory,
University of California,
Mt. Hamilton, Calif.,
and Commonwealth Observatory,
Mt. Stromlo, Canberra, Australia,
1957 *April.*

PHOTOELECTRIC OBSERVATIONS OF 12 (DD) LACERTAE

By HARLAN J. SMITH

Abstract. A total of 693 individual observations of 12 Lacertae was obtained on 9 nights in conjunction with the international cooperative work on this star.

Yale Observatory participated in the international program, organized by Dr. C. de Jager of Utrecht, for studying the complex variations of 12 (DD) Lacertae. Photoelectric runs were obtained on all possible nights during the principal period of cooperation, August 28 to September 12, 1956, and on several nights outside this interval. In the attempt to obtain maximum coverage, even so poor a night as September 4–5 was used, with results of little or no value due to rapidly changing cirrus clouds and smoke.

Observations were made with the Butler telescope, a 10-inch Clark visual refractor, from the recently vacated site of Yale Observatory near the center of the industrial city of New Haven, and close to several large factories. With this location even best nights suffer from irregular extinction. The Ashbrook photometer was used, in conjunction with a GE 1P21 photomultiplier, Corning filters 3384 and 5030 + Schott GG-13, a General Radio type 715-A DC amplifier, and a Speedomax recorder. The steep focal curve of the telescope necessitated use of a rather large diaphragm, 82″ diameter; even so, blue readings were sensitive to exact centering of the stars and thus show slightly more scatter from this cause as well as from the heavier variable extinction in blue light. To keep track of the rapidly varying extinction, observations were made alternately of variable and comparison, as quickly as possible, with sky readings taken between each star setting. Reduction by extinction coefficient being unrealistic, results were derived by direct differencing from plots of raw magnitudes of