RADIAL VELOCITIES OF 283 STARS OF SPECTRAL CLASSES R AND N*

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ABSTRACT

Radial velocities of 283 stars of spectral classes R and N are given in Table 1. By intercomparison with velocities obtained from spectrograms of high dispersion, these are found to be free from systematic errors. Thirty-four class-N stars (28 known to be light-variables) with *emission lines of hydrogen* have a mean difference of -20.4 ± 0.9 km/sec between the velocity from the emission lines (mostly $H\alpha$ alone) and that from the absorption lines.

Galactic concentration is marked for class-N stars, slight for class-R.

Mean absolute magnitudes of -2.3 ± 0.2 for class-N stars and of -0.4 ± 0.4 for class-R stars have been derived from differential galactic rotation.

Interstellar sodium lines.—The radial velocities of 2 class-N stars and 4 class-R stars are sufficiently large to separate the stellar from the interstellar sodium lines. Velocities and approximate values of the equivalent widths have been derived from the interstellar lines. The distances and absolute magnitudes have been obtained from the equivalent widths. The mean magnitude for the 2 class-N stars is -1.8 and for the 4 class-R stars, 0.0.

Stars of high velocity.—Table 4 contains 1 class-N star and 7 class-R stars, whose velocities, when freed from solar motion, are numerically larger than 100 km/sec. All 7 class-R stars have spectra with strong g-bands, but with few atomic lines.

A catalogue of radial velocities, mostly of stars of spectral classes N and R, was published by the writer eight years ago in *Mount Wilson Contributions*, No. 525.[1] This catalogue contains 191 stars, of which 187 were observed at Mount Wilson and 4 at Santiago, Chile, by the D. O. Mills Expedition. The distribution in type is: class N, 147 stars; class R, 40; class S, 3; peculiar, 1.

Some of these velocities were measured with the Hartmann spectrocomparator, but most of them with a micrometer measuring engine. The velocities for the standards used on the Hartmann spectrocomparator were based upon velocities obtained by J. H. Moore[2] for class-N stars and upon those obtained by W. C. Rufus[3] for class-R stars. For the micrometer, lines were chosen and their wave lengths determined on the basis of Moore's velocities for class N and Rufus' velocities for class R.

In *Mt. W. Contr.* No. 525 it was concluded that Moore's velocities for class-N stars and those derived both by the Hartmann comparator and by micrometric measurement at Mount Wilson needed a systematic correction of -7 km/sec, and this correction was applied. The velocities of class-R stars appear as measured originally.

Observations of class-N and class-R stars were resumed at Mount Wilson in 1935 and have been continued when conditions permitted during the next eight years. Improved photographic plates, especially the Eastman 103 F-emulsion for the yellow-red region, have greatly facilitated observing the fainter stars and have made it possible to observe many of the brighter stars with high dispersion.

Spectrograms of the faint stars of class N having a dispersion of 65 A/mm were obtained in the yellow-red region with the Cassegrain plane-grating spectrograph.[4] For

* *Contributions from the Mount Wilson Observatory, Carnegie Institution of Washington*, No. 689.

[1] *Ap. J.*, **82**, 202, 1935.

[2] *Lick Obs. Bull.*, **10**, 79, 1923.

[3] *Pub. Astr. Obs. U. Michigan*, **2**, 45, 1916.

[4] *Mt. W. Contr.*, No. 432; *Ap. J.*, **74**, 188, 1931.

class R, spectrograms with a dispersion of about 70 A/mm at $H\gamma$ for the brighter stars and 100 A/mm for the fainter ones were obtained in the blue-violet region with one-prism spectrographs. Spectrograms (dispersion either 20, 10, or 5.9 A/mm) of 30 bright class-N and 10 bright class-R stars have been obtained with the coudé plane-grating spectrograph.

Additional velocities are now available for 106 of the stars in *Mt. W. Contr.* No. 525 and for 45 class-N and 48 class-R stars not previously measured. These 93 stars, observed for the first time, were largely selected from the *Henry Draper Catalogue* and from the lists of discoveries made by objective prism at Mount Wilson[5] and at the Dearborn Observatory.[6] The improved values for velocities in *Contribution* No. 525, together with the velocities for the 93 other stars, make it desirable to issue a completely new catalogue.

The catalogue.—All stars of classes N and R with measured radial velocities are listed in Table 1. Of the 283 stars included, all have been observed at Mount Wilson except 4 class-N stars observed at Santiago, Chile. The designation MSB indicates the Mount Wilson lists of stars discovered on objective-prism plates;[5] Lee indicates stars similarly discovered at the Dearborn Observatory.[6]

The magnitudes have been taken from various sources. Visual magnitudes for non-variable stars are from the *Henry Draper* and *Bonner Durchmusterung* catalogues, from the *Dearborn Observatory Annals*, and, lastly, if no value is available, from estimates by the writer at the finder or at the guiding telescope. These estimates are in parentheses. The magnitudes for the maxima and minima of variable stars are, for the most part, from Schneller's "Catalogue and Ephemeris of Variable Stars."[7] Photographic magnitudes are underscored.

All the stars are placed in one or the other of the Harvard spectral classes N or R. Those in class N have not, however, been subdivided with the letters a, b, and c, as in the Harvard classification, or with the numbers 1–9, as in C. D. Shane's[8] classification. Only the broad classification N has been used, with e appended when the spectrum has bright lines and p when the spectrum is peculiar.

Keenan and Morgan[9] have published a new system of classification for stars with carbon bands. Two of the data which they use as criteria are given in Table 1; the eleventh column contains estimates of the strength of the D lines on an arbitrary scale of 1–9, and the twelfth column, estimates of the strength of the Swan band-head at λ 6192 on a scale of 1–5. By means of these two columns at least a rough conversion of class-N stars to the classification of Keenan and Morgan can be made, if desired.

The subdivisions of class R in the tenth column of Table 1 resemble closely those of the *Henry Draper Catalogue*, except that the progression in the strength of the isotope bands of $C^{12}C^{13}$ has here relatively more influence. These class-R stars may be put into Keenan and Morgan's classification by using the nearly linear relation which it bears to the *Henry Draper* classification.[10]

Although their classification may provide a better temperature sequence than the Harvard classification, it is still unsatisfactory in some respects; it seems not to be consistent with the observed relatively low intensity of the D lines in the spectrum of some extremely red class-N stars, like VX Andromedae, for example. The contents of the tenth, eleventh, and twelfth columns may therefore serve as a compromise classification until such difficulties are removed.

The mean absorption-line velocities in Table 1 have been formed with appropriate

[5] *Pub. A.S.P.*, **45**, 306, 1933; **54**, 107, 1942.

[6] *Dearborn Obs. Annals*, **4**, Part 16, 1940.

[7] *Kleinere Veröff. Sternwarte Berlin-Babelsberg*, No. 21, 1939.

[8] *Lick Obs. Bull.*, **13**, 123, 1928.

[9] *Ap. J.*, **94**, 501, 1941.

[10] *Ibid.*, Fig. 1.

weight for the velocities of class-R stars by Rufus and of class-N stars by Moore. A systematic correction of −7 km/sec was first applied to Moore's values.

The letters accompanying the velocities express the writer's judgment of the probable accuracy. The uncertainties are about as follows: a, 1 km/sec; b, 2–3 km/sec; c, 4–5 km/sec; d, 6–8 km/sec. Velocities with the letter e usually depend upon a single low-dispersion spectrogram taken primarily to check the spectral classification. It was not practicable to obtain more spectrograms. The underscored velocities depend largely or wholly upon those obtained from coudé spectrograms. The emission-line velocities in the last column of Table 1 are derived for the most part from $H\alpha$.

The radial velocities from absorption lines.—The velocities of class-N and class-R stars in Table 1 are on the same basis as those in *Mt. W. Contr.* No. 525. Before using these velocities it had to be ascertained whether they were free from systematic errors, which was done by comparing the velocities obtained with the coudé spectrograph with those for the same stars with the smaller dispersions.

The velocities from coudé spectrograms could be so used because experience has shown that this spectrograph is practically free from instrumental errors and because the following considerations assured accurate wave lengths for the absorption lines used for velocity measurement. Many atomic lines with well-known wave lengths are well isolated for measurement in the blue-violet region of classes N and R and in the yellow-red region of early class R. Lines of comparable quality in the yellow-red region of the spectrum of late class-R and class-N stars belong to the band spectrum of cyanogen. Wave lengths for these lines were obtained by referring them to the lines in the neon comparison spectrum on a coudé spectrogram of the carbon arc. Comparison showed that the weighted mean difference, coudé *minus* low dispersion, for 26 suitably observed class-N stars is -0.4 ± 0.6 km/sec and for 7 class-R stars $+0.0 \pm 0.8$ km/sec. There appears, therefore, no reason to apply systematic corrections to the velocities of class-R or class-N stars obtained with lower dispersion.

Velocities from bright hydrogen lines.—Thirty-four stars of class N with hydrogen emission lines appear in Table 1. All are known variable stars with the exception of six of the Mount Wilson objective-prism discoveries and one of Lee's stars. These also may turn out to be variable when adequately observed. At any rate, the evidence is strong that emission lines of hydrogen are favored by variability. Sufficient spectroscopic observations have been made at all phases of a number of these variables to show that the emission lines are at their maximum strength near maximum light and practically vanish for a considerable interval before and after light-minimum.

For the most part, the emission-line velocity has been derived from $H\alpha$ alone. This velocity is invariably smaller algebraically than the absorption-line velocity. The weighted mean difference (emission *minus* absorption) for these 34 stars is -20.4 ± 0.9 km/sec. The correlation of this difference with the length of the period of light-variation is weak, there being, perhaps, a slight tendency to larger negative values for the longer periods.

Galactic distribution.—Stars of class N are plotted by galactic co-ordinates in Figure 1, which shows marked galactic concentration; only about 10 per cent of the stars are more than 30° from the galactic plane, and these are predominantly bright stars whose real distances from the plane cannot be great. In contrast, stars of magnitude 9.0 or fainter lie for the most part within 10° of the galactic plane. The galactic concentration of stars of class R (Fig. 2) is not marked.

The mean absolute magnitudes.—Studies of the motions of distant celestial objects have amply demonstrated the differential effects of galactic rotation. This rotation produces a double sine-curve of velocity variation for the 360° of galactic longitude. Previous values of the semi-amplitude of this curve for a distance of 1000 parsecs range from 15 to about 20 km/sec. A recent discussion by R. E. Wilson[11] of the best available data gives 17.7 km/sec/kiloparsec.

[11] *Mt. W. Contr.*, No. 631; *Ap. J.*, **92**, 170, 1939.

TABLE 1

RADIAL VELOCITIES OF STARS OF CLASSES R AND N

Star	HD or MSB	1900 R.A.	1900 Decl.	Galactic l	Galactic b	Magnitude Max.	Magnitude Min.	Period (Days)	Spect.	Intensity Na	Intensity C_2	Vel. (Km/sec) Abs.	Vel. (Km/sec) Em.
UX Cas	MSB 43	$0^h\ 8^m.0$	+62°54'	86°	+ 1°	12.0	13.8	...	R2	.	.	-11 d	...
ST Cas	1306	12.2	+49 44	85	-12	7.5	9.0	...	N	5	4	-43 c	...
VX And	1546	14.6	+44 9	85	-18	8.1	9.5	367?	N	5	4	+ 9 a	...
MSB 44	......	17.2	+58 34	87	- 4	(9.8)	....	...	N	6	3	-46 c	...
......	1994	19.1	+53 44	87	- 8	9.7	....	...	R6	.	.	-36 c	...
AQ And	2342	22.2	+35 2	86	-27	7.8	8.0	332	N	5	4	-14 a	...
......	5223	48.9	+23 32	91	-32	8.8	....	...	R3	.	.	-232 a	...
MSB 45	......	1 5.0	+53 11	94	- 9	(10.5)	....	...	Ne	4	3	-19 c	-44
Z Psc	7561	10.6	+25 14	98	-36	7.4	8.1	...	N	7	3	+18 a	...
R Scl	8879	22.4	-33 4	211	-80	6.2	8.8	376	Np	6	4	- 8 c	...
WW Cas	MSB 1	27.1	+57 14	96	- 4	9.1	11.7	...	N	6	4	-59 b	...
......	10636	38.7	+53 28	99	- 8	9.9	....	...	R6	.	.	-30 c	...
X Cas	......	49.8	+58 46	99	- 1	8.4	13.1	425	Ne	5	4	-55 a	-80
V Ari	13826	2 9.6	+11 47	122	-44	8.3	9.0	...	RO	0	3	-176 a	...
MSB 2	......	20.1	+51 37	105	- 8	(9.5)	....	...	N	6	3	-45 b	...
R For	......	24.8	-26 33	181	-66	8.1	13.3	393	Ne	4	2	+30 b	+ 2
......	16115	30.2	- 9 53	150	-58	8.3	....	...	R4	.	.	+16 a	...
VZ Per	MSB 46	31.6	+55 20	106	- 4	13.3	13.6	...	R4	.	.	-16 c	...
UY And	16326	32.1	+38 44	113	-18	11.0	14.0	149	N	6	4	-63 b	...
......	19557	3 3.7	+57 31	108	0	8.1	....	...	R6	.	.	- 8 a	...
......	19881	6.7	+47 27	114	- 8	9.2	....	...	Np	7	3	+ 8 b	...
......	20234	10.0	-57 41	240	-50	5.7	....	...	N	.	.	+14 a	...
Y Per	21280	20.9	+43 50	118	- 9	8.3	11.0	254	R4e	2	2	- 9 a	-14
U Cam	22611	33.2	+62 19	109	+ 7	6.9	9.0	419	N	5	4	- 3 c	...
+51°762	MSB 3	33.9	+51 11	115	- 2	8.9	....	...	N	6	4	+ 6 c	...
AC Per	MSB 4	38.1	+44 28	120	- 7	10.2	12.3	...	N	6	4	-32 d	...
......	25408	57.2	+61 32	111	+ 8	7.9	....	...	R8	.	.	- 8 a	...
+50°920	MSB 47	4 4.0	+51 4	119	+ 1	9.5	....	...	R3	.	.	-11 b	...
SY Per	MSB 6	8.9	+50 23	120	+ 1	9.5	12.5	476	Ne	4	4	- 1 d	-39
......	27108	11.8	+26 6	138	-16	(10.2)	....	...	R4	.	.	-81 b	...
MSB 7	......	13.0	+40 53	128	- 5	(9.0)	....	...	N	5	3	- 2 e	...
MSB 8	......	22.9	+39 38	129	- 5	(9.0)	....	...	N	7	4	+ 9 c	...
AV Per	MSB 9	32.6	+41 26	130	- 2	13.5	15.0	...	N	5	5	+51 c	...
ST Cam	30243	40.8	+67 59	110	+16	7.0	8.3	...	N	6	4	-12 a	...
......	30443	42.7	+34 49	136	- 5	9.0	....	...	R4	.	.	+70 a	...

T Cae	30593	4h43m.8	-36°23'	205°	-39°	8.7	10.3	...	N	6	4	- 7 e	...
......	30710	44.9	+15 37	151	-16	10.1	....	...	N	6	2	+38 c	...
TT Tau	30755	45.2	+28 21	142	- 9	8.1	8.8	166	N	6	3	+16 a	...
+38°955	MSB 10	45.7	+38 20	133	- 2	8.8	....	...	N	8	2	+32 b	...
AU Aur	MSB 11	46.8	+49 46	125	+ 5	13.5	[15	...	Ne	7	2	- 3 b	-23
Lee 8	......	47.6	+22 35	147	-12	9.4	....	...	N	6	3	+48 d	...
R Lep	31996	55.0	-14 57	182	-31	6.1	9.7	440	Ne	6	5	+34 a	+21
......	32088	55.6	+50 29	125	+ 7	9.0	....	...	N	4	3	-12 e	...
W Ori	32736	5 0.2	+ 1 2	167	-21	5.9	7.7	200	N	5	4	+16 a	...
TX Aur	33016	2.2	+38 52	135	+ 1	8.5	9.2	330	N	4	4	- 6 c	...
SY Eri	33404	4.9	- 5 38	173	-24	8.0	9.6	...	N	7	3	+ 8 d	...
+11°755	Lee 16	10.4	+11 52	158	-14	9.4	....	...	N	5	3	-11 c	...
......	34467	12.5	+35 41	139	+ 1	9.1	....	...	N	7	3	+15 d	...
UV Aur	34842	15.3	+32 24	142	- 1	7.9	10.1	350	Ne	8	1	-10 a	-15
Lee 18	......	15.8	+ 7 16	163	-15	10.4	....	...	N	5	3	-17 e	...
S Aur	35556	20.5	+34 4	141	+ 1	8.3	[12	591	N	6	4	+ 3 d	...
CM Aur	MSB 48	22.1	+43 21	134	+ 6	13	14.5	...	N	6	4	-28 e	...
+3°924	Lee 21	24.1	+ 3 23	168	-15	9.5	....	...	N	3	2	+14 c	...
RT Ori	36602	27.8	+ 7 4	165	-12	7.5	8.5	...	N	6	4	+ 5 c	...
S Cam	36972	30.2	+68 45	111	+20	7.8	10.8	324	R8e	.	.	-13 e	-17
......	37212	31.7	-25 48	197	-26	7.9	....	...	N	4	3	+40 b	...
TU Tau	38218	39.1	+24 23	152	- 1	8.7	9.5	...	N	5	3	-24 c	...
Y Tau	38307	39.7	+20 39	155	- 3	6.9	8.9	241	N	5	3	+17 d	...
+15°921	MSB 13	39.7	+15 28	159	- 5	9.5	....	...	N	5	4	+22 e	...
AF Aur	38521	41.4	+44 50	134	+10	8.5	9.5	...	N	5	4	-11 e	...
......	38572	41.7	+30 36	147	+ 2	9.0	9.3	...	N	8	3	+16 d	...
AZ Aur	MSB 15	54.2	+39 42	140	+10	10.5	15.5	416	Ne	8	2	+84 a	+65
XZ Aur	......	56.9	+47 17	133	+13	12.0	13.2	...	N	4	4	+19 c	...
TU Gem	42272	6 4.7	+26 3	153	+ 5	7.4	8.3	...	N	6	3	+48 c	...
+8°1263	Lee 38	12.2	+ 8 34	169	- 2	9.5	....	...	N	6	4	+46 d	...
-0°1246	MSB 16	12.7	- 0 12	177	- 6	9.5	....	...	N	6	4	+34 e	...
MSB 17	......	13.4	- 1 7	179	- 7	(9.2)	....	...	N	4	2	+80 e	...
V Aur	44388	16.5	+47 45	134	+17	8.3	[12.2	357	Ne	5	4	+ 6 e	+ 3
BN Mon	MSB 18	16.5	+ 7 21	171	- 2	13.0	15.3	...	N	6	4	+28 a	...
ZZ Gem	44653	17.8	+25 4	155	+ 7	8.9	9.9	...	Ne	3	1	+76 e	+64
-7°1402	MSB 20	18.5	- 7 25	184	- 8	9.5	....	...	N	5	4	+52 d	...
BL Ori	44984	19.8	+14 48	164	+ 2	6.6	....	...	N	6	3	+13 a	...
AB Gem	45087	20.3	+19 8	161	+ 5	8.2	9.8	...	N	6	4	+11 b	...
-26°2983	MSB 22	20.5	-27 1	202	-16	8.6	....	...	N	5	3	+23 e	...
+12°1177	MSB 23	25.3	+12 33	167	+ 3	9.4	....	...	N	3	4	- 8 d	...
Lee 50	......	26.0	+16 11	164	+ 4	10.6	....	...	N	6	2	+17 e	...
RV Aur	46321	27.6	+42 34	141	+16	9.2	9.6	...	N	3	3	-52 e	...
+16°1194	MSB 49	28.5	+16 9	164	+ 5	9.2	....	...	N	8	3	+ 3 e	...
UU Aur	46687	29.7	+38 31	144	+15	6.2	6.7	235	N	6	4	+12 a	...
......	47396	33.3	+22 42	159	+ 9	(9.2)	....	...	N	3	3	+45 e	...

TABLE 1--Continued .

Star	HD or MSB	1900 R.A.	1900 Decl.	Galactic l	Galactic b	Magnitude Max.	Magnitude Min.	Period (Days)	Spect.	Intensity Na	Intensity C_2	Vel.(Km/sec) Abs.	Vel.(Km/sec) Em.
Lee 54	......	$6^h34^m.7$	+18°50'	163°	+ 8°	10.5	....	...	N	4	4	+38 e	...
VW Gem	47883	35.7	+31 33	151	+14	8.6	8.8	110±	N	5	3	+14 c	...
MSB 50	......	38.5	- 8 40	188	- 5	(9.0)	....	...	N	4	4	+32 e	...
......	48664	39.4	+ 3 25	177	+ 1	9.3	....	...	N	6	2	+27 d	...
MSB 51	......	41.7	-12 49	190	- 6	(9.0)	....	...	N	3	2	+67 e	...
Lee 60	......	42.4	+ 0 47	179	+ 1	10	....	...	N	5	4	+77 e	...
W Mon	......	47.5	- 7 2	187	- 2	9.7	[12.2	...	N	4	1	0 d	...
......	50436	48.2	- 4 27	185	0	9.2	10.4	...	N	7	3	+38 d	...
MSB 26	......	50.2	+ 6 29	176	+ 5	(9.0)	....	...	Ne	3	2	+43 d	+19
UW Aur	50949	50.3	+41 14	143	+20	9.6	12.6	530	R6p	0	4	- 7 c	...
BG Mon	MSB 27	50.9	+ 7 13	175	+ 6	12	13.5	240	N	5	3	+71 c	...
......	51208	51.3	-42 14	219	-17	6.0	....	...	N	8	2	+32 a	...
+6°1451	MSB 28	51.7	+ 6 29	176	+ 6	9.5	....	...	N	5	4	+57 e	...
RV Mon	51620	53.0	+ 6 18	176	+ 6	7.0	8.2	225	N	6	4	+16 b	...
......	52432	56.1	- 3 6	185	+ 2	7.5	....	...	R6	.	.	+21 a	...
RY Mon	MSB 29	7 2.1	- 7 24	189	+ 1	7.7	9.1	466	N	4	3	+ 2 c	...
W CMa	54361	3.4	-11 46	193	- 1	6.9	7.5	...	N	6	4	+21 d	...
......	......	7.0	+ 0 58	182	+ 7	(11.6)	....	...	R2	.	.	+ 8 b	...
VX Gem	55284	7.2	+14 46	171	+12	10.8	[14.9	377	Nep	8	2	+53 d	+42
MSB 52	......	9.5	-19 32	201	- 3	(9.0)	....	...	N	6	2	+66 c	...
-17°1866	MSB 53	10.1	-17 13	198	- 2	(9.0)	....	...	N	6	3	+52 e	...
+5°1606	MSB 30	10.3	+ 5 14	179	+ 9	9.5	....	...	N	4	4	+52 d	...
RU Cam	56167	10.9	+69 52	118	+29	7.9	9.0	222	KO-RO	.	.	-24 a	...
MSB 54	......	10.9	-17 20	198	+ 2	(10.5)	....	...	N	3	3	+87 e	...
BM Gem	57160	14.9	+25 10	161	+19	11.5	12.1	...	N	4	3	+98 e	...
......	57884	18.1	- 4 2	188	+ 6	9.3	....	...	N	4	3	+55 c	...
......	58195	19.4	-22 47	205	- 2	9.2	....	...	N	3	2	+44 c	...
......	58337	20.1	+22 7	164	+18	10.0	....	...	R4	.	.	+ 4 e	...
......	58364	20.2	+22 5	164	+18	9.8	....	...	R4	.	.	- 3 c	...
......	58385	20.3	- 2 57	187	+ 7	9.1	....	...	N	3	1	+64 d	...
......	59643	25.8	+24 44	161	+18	8.2	....	...	R6	.	.	+41 a	...
......	60826	31.3	+ 2 18	184	+13	8.7	9.1	...	N	7	4	+44 b	...
......	60952	31.8	-23 22	206	0	11.6	....	...	N	3	3	+10 c	...
MSB 55	......	41.0	-11 43	198	+ 7	(9.5)	....	...	N	4	4	+32 c	...
W CMi	63353	43.4	+ 5 40	182	+17	9.8	11.3	...	R6	.	.	+21 e	...

MSB 31	......	$7^h45^m.0$	- 0°38'	189°	+14°	(9.0)	....	...	R8	.	.	+ 4 d	...
MSB 32	......	52.7	- 0 24	189	+16	(9.6)	....	...	Ne	4	2	+25 c	- 6
MSB 33	......	57.7	- 1 51	191	+16	(9.5)	....	...	N	4	4	+26 e	...
RT Pup	67190	8 1.7	-38 29	222	- 3	9.3	10.2	...	N	.	.	+28 d	...
RU Pup	67507	3.2	-22 37	210	+ 6	9.4	11.6	...	N	6	4	+23 e	...
RY Hya	70072	14.9	+ 3 5	189	+22	8.3	9.6	535	Ne	5	3	+17 c	- 8
......	70138	15.2	-17 57	208	+11	9.3	....	...	R7	.	.	+24 b	...
Lee 98	......	15.4	+ 5 31	187	+24	10.0	....	...	R5	.	.	+29 b	...
T Lyn	......	16.4	+33 50	156	+34	8.0	12.0	416	Ne	6	2	+ 6 b	-12
AC Pup	......	18.2	-15 35	205	+13	8.9	10.1	...	N	5	3	+41 c	...
Lee 99	......	36.4	+ 7 47	187	+29	10.6	....	...	R4	.	.	+31 c	...
......	75021	42.4	-29 21	220	+ 9	7.6	....	...	R8	.	.	+11 a	...
X Can	76221	49.7	+17 37	178	+37	6.1	6.6	130	N	6	4	- 1 a	...
......	76396	50.8	+51 49	134	+41	8.8	....	...	R4	.	.	-52 e	...
T Can	......	51.0	+20 14	175	+37	8.0	10.2	500	R6	2	3	+ 7 a	...
......	76846	53.6	+34 9	157	+42	9.2	....	...	R1	.	.	+25 a	...
......	77234	56.2	+50 29	135	+43	9.5	....	...	R6	.	.	+ 5 a	...
......	78278	9 2.2	+21 58	174	+41	(10.2)	....	...	R6	.	.	+19 b	...
......	79319	8.3	+14 37	184	+39	8.9	....	...	R6	.	.	+ 4 a	...
MSB 57	......	9.0	-22 59	219	+18	(9.0)	....	...	Ne	5	2	-10 b	-34
......	85066	44.4	+53 7	130	+49	(9.7)	....	...	R3	.	.	-24 a	...
W Sex	85319	45.9	- 1 33	208	+39	10.3	12.3	...	N	4	2	+59 a	...
Y Hya	85405	46.4	-22 32	226	+24	6.5	8.0	95	N	5	4	+ 3 a	...
X Vel	86111	51.3	-41 7	239	+11	9.5	11.8	...	N	5	4	- 7 e	...
......	88539	10 7.5	-34 50	238	+18	7.0	....	...	N	4	2	+ 4 b	...
......	88627	7.9	+77 36	99	+37	(10.0)	....	...	R6	.	.	-92 b	...
U Ant	91793	30.8	-39 3	244	+16	8.3	9.3	168?	N	5	4	+37 b	...
U Hya	92055	32.6	-12 52	229	+39	4.5	6.3	...	N	6	4	-26 a	...
......	92839	38.1	+67 56	106	+46	6.3	....	...	N	3	3	- 5 a	...
V Hya	......	46.8	-20 43	237	+35	6.7	12.0	532	N	6	4	- 8 a	...
......	95405	55.7	-25 19	242	+31	9.0	....	...	Kp	.	.	+12 e	...
+2°2446	Lee 106	11 28.6	+ 2 18	233	+59	9.5	....	...	R2	.	.	+20 b	...
......	100764	30.7	-14 2	246	+45	8.7	....	...	R2	.	.	+ 5 b	...
Lee 107	......	50.5	+13 8	229	+71	11.3	....	...	R5	.	.	-137 a	...
S Cen	107957	12 19.2	-48 53	266	+13	8.1	9.5	...	Np	.	.	-41 a	...
SS Vir	108105	20.1	+ 1 20	259	+63	7.2	9.0	354	Ne	5	4	+ 2 a	-22
......	108683	24.0	-37 42	266	+24	9.3	....	...	N	5	4	-28 d	...
Y CVn	110914	40.4	+45 58	90	+72	4.8	6.0	316	N	5	4	+12 a	...
RU Vir	111166	42.2	+ 4 42	271	+66	8	12.6	439	R3e	.	.	+ 2 a	-21
RY Dra	112559	52.5	+66 32	88	+51	6.1	7.1	...	N	.	.	-20 d	...
......	112869	54.7	+38 20	74	+79	9.2	9.6	...	R6p	0	4	-135 a	...
......	113801	13 1.1	-19 31	276	+42	8.7	....	...	K5R	.	.	-16 c	...
Z Lup	128033	14 29.5	-42 56	290	+15	8.2	9.6	...	N	6	2	+ 8 c	...
......	133332	58.8	- 2 28	323	+45	10.6	....	...	R6	.	.	-28 e	...
X TrA	134453	15 4.8	-69 42	282	-11	8.2	10.0	...	N	.	.	- 4 a	...

TABLE 1--Continued

Star	HD or MSB	1900 R.A.	1900 Decl.	Galactic l	Galactic b	Magnitude Max.	Magnitude Min.	Period (Days)	Spect.	Intensity Na	Intensity C_2	Vel. (Km/sec) Abs.	Vel. (Km/sec) Em.
......	137613	$15^h21^m.9$	-24°49'	310°	+25°	7.4	....	...	R0	.	.	+55 a	...
Lee 114	......	22.6	+ 1 3	332	+42	11.4	....	...	R4	.	.	-23 d	...
V CrB	141826	45.9	+39 52	30	+50	7.2	12.0	357	Ne	6	2	-115 a	-131
RR Her	144578	16 1.5	+50 46	46	+46	7.8	9.5	242	Nep	6	1	-37 a	-46
......	145777	7.6	-14 57	326	+24	10.7	....	...	R4	.	.	+15 c	...
......	148173	21.1	-43 27	306	+ 2	9.3	....	...	N	4	2	+ 7 c	...
V Oph	148182	21.2	-12 12	331	+23	7.0	10.5	301	Ne	.	.	-40.a	-58
SU Sco	......	34.2	-32 11	317	+ 8	7.5	9.0	...	N	3	3	-19 c	...
MSB 58	......	56.2	-32 31	320	+ 5	(9.0)	....	...	Ne	3	2	+ 1 d	-19
......	156074	17 10.4	+42 15	37	+34	7.7	....	...	R0	.	.	-16 a	...
-40°11335	MSB 59	13.9	-40 16	316	- 3	9.3	....	...	N	6	3	- 9 d	...
-36°11460	......	17.0	-36 24	319	- 1	9.5	....	...	R3	.	.	-67 b	...
-29°13477	MSB 60	17.7	-29 14	325	+ 3	9.0	....	...	N	5	3	-24 b	...
-39°11452	MSB 34	20.7	-39 55	316	- 4	10	....	...	N	6	4	-30 e	...
TW Oph	158377	23.8	-19 24	334	+ 7	7.8	....	...	N	5	4	+14 c	...
TT Sco	160205	33.5	-41 35	316	- 7	9.0	[11.2	...	N	6	4	+ 8 c	...
......	160591	35.7	-35 12	322	- 4	10.7	11.6	...	R8	2	4	-57 e	...
SZ Sgr	161208	39.1	-18 37	336	+ 4	8.5	9.8	...	N	6	3	+19 b	...
SX Sco	161511	40.8	-35 39	322	- 6	9.6	11.1	128?	N	5	3	-36 c	...
......	163838	53.2	+64 9	60	+30	(10.2)	....	...	R3	.	.	-38 b	...
Lee 115	......	53.9	+13 10	6	+16	(10)	....	...	R4	.	.	-100 c	...
T Dra	......	54.9	+58 14	53	+29	7.5	14.0	425	Ne	8	3	-23 a	-43
-19°4805	MSB 61	55.5	-19 10	338	0	9.7	....	...	N	5	3	+17 e	...
W CrA	......	58.4	-39 20	321	-10	10.0	[11	109	R3	.	.	-103 d	...
-28°14163	MSB 62	18 1.2	-28 31	331	- 5	(9.8)	....	...	N	7	4	-11 e	...
......	166097	4.0	+ 9 26	4	+12	10.0	....	...	R4	.	.	-19 b	...
MSB 63	......	4.2	-26 55	332	- 5	(10.0)	....	...	N	7	2	- 5 c	...
......	......	8.1	+14 54	10	+14	(10.3)	....	...	R4	.	.	+ 8 b	...
......	168227	13.6	-15 39	344	- 2	9.0	9.8	...	R6	.	.	-19 c	...
Lee 117	......	19.4	+ 6 0	3	+ 7	11.2	....	...	R0	.	.	+34 b	...
......	170282	23.4	-38 29	323	-14	10.3	....	...	R5	.	.	-75 c	...
SS Sgr	170495	24.6	-16 59	343	- 4	11.0	12.0	...	R3	1	2	0 c	...
TY Oph	170831	26.4	+ 4 19	2	+ 5	9	10	...	N	5	3	-19 b	...
T Lyr	......	28.9	+36 54	33	+18	7.8	9.6	...	R6	1	2	-12 b	...
RX Sct	171804	31.7	- 7 41	352	- 2	9.7	12.0	...	N	6	4	- 7 b	...

RV Sct	173138	18h38m.7	-13°20'	348°	- 6°	8.6	10.1	...	R3	2	3	- 4 c	...
......	173291	39.4	+36 51	33	+17	8.1	....	...	N	6	4	- 5 a	...
......	173409	40.0	-31 28	331	-14	9.2	....	...	RO	.	.	-65 e	...
+5°3950	MSB 64	42.6	+ 5 20	5	+ 1	9.5	....	...	N	6	4	-17 c	...
S Sct	174325	44.9	- 8 1	354	- 5	6.4	7.3	144?	N	4	4	0 a	...
T Sct	175377	50.0	- 8 19	354	- 6	8.8	9.3	...	N	6	2	+15 c	...
......	175893	52.4	-29 38	335	-16	9.3	....	...	RO	.	.	+42 c	...
UV Aql	176200	54.0	+14 14	14	+ 4	9.6	11.6	355	N	5	4	+21 b	...
V Aql	177336	59.1	- 5 50	357	- 7	6.5	8.0	...	N	6	4	+37 a	...
......	178316	19 3.0	-17 26	347	-13	10.6	....	...	R2	.	.	-42 c	...
SV Sge	......	3.8	+17 29	18	+ 3	10.8	14.5	...	R2	.	.	+ 4 b	...
......	179153	6.3	- 1 33	2	- 6	10.8	11.7	...	R8	2	3	+22 d	...
......	179355	7.1	-31 7	335	-20	11.3	....	...	R3	.	.	+63 d	...
MSB 65	......	9.8	+27 8	27	+ 6	(9.0)	....	...	R3	2	2	+13 e	...
MSB 66	......	12.8	+21 45	22	+ 4	(9.0)	....	...	N	5	4	-20 e	...
......	180953	13.4	-16 5	349	-15	7.2	....	...	N	6	4	-45 a	...
U Lyr	MSB 35	16.7	+37 37	37	+10	8.3	12.0	449	Ne	6	3	- 3 b	-36
......	182040	17.7	-10 53	354	-13	7.0	....	...	R2	.	.	-47 a	...
UX Dra	183556	25.1	+76 23	75	+24	6.1	7.0	...	N	4	3	+ 6 a	...
V374 Aql	Lee 130	25.1	- 1 3	4	-11	12.5	15.1	...	Ne	7	2	+11 c	-11
AW Cyg	MSB 36	25.8	+45 50	46	+12	8.0	10.2	...	N	5	3	-12 c	...
AQ Sgr	184283	28.6	-16 35	351	-18	8.5	9.7	...	N	7	4	+14 a	...
V391 Aql	......	33.0	+ 6 30	11	- 9	12.8	13.8	...	N	6	3	-28 b	...
......	......	35.4	+ 8 48	15	- 8	11.8	....	...	RO	.	.	+42 b	...
HV Cyg	MSB 68	36.6	+31 32	34	+ 4	13.2	[16.3	195+	N	6	4	+24 d	...
TT Cyg	186047	37.1	+32 23	35	+ 4	7.3	8.4	120	N	4	3	-49 a	...
UW Sgr	186665	40.6	-18 24	350	-22	8.4	10.2	...	N	7	1	-13 c	...
......	187216	43.8	+85 9	85	+27	9.6	....	...	R3	.	.	-129 c	...
......	188934	52.5	- 0 2	9	-16	9.8	....	...	R4	.	.	+57 c	...
AX Cyg	189256	54.0	+43 59	47	+ 7	7.4	7.9	...	N	5	4	- 6 a	...
......	189605	55.7	- 7 39	2	-20	10.8	....	...	R4	2	4	+48 c	...
......	189711	56.3	+ 9 14	17	-12	8.7	....	...	N	3	2	-168 a	...
......	190048	58.0	+20 48	28	- 7	9.2	....	...	N	3	3	-14 b	...
MSB 69	......	58.1	+39 42	43	+ 4	(9.5)	....	...	N	6	3	+ 8 e	...
MSB 37	......	58.6	+30 23	36	- 1	(9.4)	....	...	N	4	4	+12 d	...
X Sge	190606	20 0.7	+20 22	27	- 7	8.7	9.7	196	N	5	4	+26 e	...
AY Cyg	......	6.3	+41 12	45	+ 3	11.9	12.4	...	N	6	3	+21 e	...
SV Cyg	191738	6.4	+47 33	52	+ 8	8.5	9.4	...	R3	2	2	- 8 c	...
RY Cyg	191783	6.6	+35 39	40	0	9.2	11.0	...	N	6	4	+13 e	...
RS Cyg	192443	9.8	+38 26	43	+ 2	7.5	8.7	422	Ne	8	4	-50 a	-62
RT Cap	192737	11.3	-21 38	350	-29	8.6	10.4	211	N	5	4	-30 d	...
WX Cyg	193368	14.8	+37 9	43	0	9.0	12.2	410	Ne	8	2	+32 a	+ 9
U Cyg	193680	16.5	+47 35	52	+ 6	6.1	11.8	457	Ne	8	2	+13 a	- 4
Lee 143	......	20.9	+17 34	28	-13	(9)	....	...	N	4	2	+51 c	...
MSB 70	......	21.4	+55 55	58	+ 9	(9.5)	....	...	N	3	2	+25 c	...

TABLE 1--Continued

Star	HD or MSB	1900 R.A.	1900 Decl.	Galactic l	Galactic b	Magnitude Max.	Magnitude Min.	Period (Days)	Spect.	Intensity Na	Intensity C_2	Vel. (Km/sec) Abs.	Vel. (Km/sec) Em.
......	195435	20h26m.2	-12°13'	1°	-29°	9.6	....	...	R6	.	.	-52 c	...
BD Vul	......	33.0	+26 8	36	-10	12	15	448?	Ne	5	2	+31 c	+ 7
MSB 71	......	33.8	+36 30	45	- 4	(9.7)	....	...	N	4	3	+18 d	...
MSB 38	......	33.9	+59 44	63	+11	(9.5)	....	...	N	3	4	-34 c	...
V Cyg	MSB 39	38.1	+47 48	54	+ 3	6.8	13.8	429	Ne	8	2	+ 3 a	-24
+31°4201	MSB 40	39.4	+31 46	42	- 7	9.2	....	...	N	5	3	-26 c	...
......	197604	39.7	+34 43	44	- 7	9.8	....	...	R4	.	.	+21 c	...
......	198140	43.2	-19 24	355	-36	10.3	....	...	R1	.	.	+46 d	...
+32°3954	MSB 41	45.2	+32 51	44	- 7	9.2	....	...	N	5	4	-11 e	...
DS Cyg	198681	46.9	+45 2	53	0	12.9	15.1	...	N	5	3	- 6 c	...
RV Aqr	......	21 0.7	- 0 36	17	-31	8.7	[15	453	Ne	7	2	- 1 b	-25
T Ind	202874	13.6	-45 27	323	-46	7.2	8.9	...	N	.	.	+ 2 a	...
+2°4338	Lee 150	14.1	+ 2 47	23	-31	9.5	....	...	R1	.	.	-50 b	...
YY Cyg	......	18.6	+41 58	54	- 7	8.5	9.5	387	N	6	3	-10 c	...
......	205777	32.5	+60 28	69	+ 6	10.3	....	...	N	5	4	-15 b	...
S Cep	206362	36.4	+78 10	81	+19	7.9	13.1	482	Ne	.	.	-34 b	-47
DS Peg	206570	37.8	+35 3	53	-14	6.0	7.0	...	N	4	4	+10 a	...
RV Cyg	206750	39.1	+37 34	56	-11	7.1	9.3	75	N	5	3	+ 2 a	...
LW Cyg	208512	51.6	+50 2	64	- 4	10.5	11.5	...	R3	2	4	-18 b	...
RX Peg	208526	51.7	+22 24	47	-25	7.7	8.6	175	N	3	2	-27 a	...
......	209596	59.5	+45 5	63	- 8	(9.5)	....	...	N	6	2	-18 c	...
......	209621	59.7	+20 34	47	-27	8.8	....	...	R3	.	.	-381 a	...
RZ Peg	209890	22 1.5	+33 2	56	-18	9.0	12.4	440	Ne	9	2	-27 d	-60
MSB 72	......	28.5	+58 9	73	0	(9.5)	....	...	N	4	3	-18 c	...
Lee 153	......	40.0	+17 36	54	-35	(9)	....	...	Ne	5	2	+17 b	-22
......	215484	40.4	+61 12	76	+ 2	9.0	....	...	N	4	3	-30 c	...
+48°3827	MSB 73	40.7	+48 57	71	- 9	9.4	....	...	N	5	4	-13 b	...
MSB 74	......	41.1	+56 5	74	- 2	(9.1)	....	...	N	4	4	-50 b	...
TX Lac	215673	41.8	+54 33	74	- 3	11.5	12.1	240	R6	.	.	-28 b	...
......	216649	49.5	- 7 30	32	-57	(10.5)	....	...	R3	.	.	-42 b	...
TV Lac	216913	51.9	+53 41	74	- 5	11.7	12.7	...	N	.	.	-17 c	...
VY And	......	57.3	+45 21	72	-13	9.5	11.0	149	R8	2	4	- 7 c	...
......	218851	23 6.2	+45 46	73	-14	(9.5)	....	...	R2	.	.	-49 b	...
......	218875	6.3	-21 32	11	-68	9.4	10.8	...	R0	.	.	+32 c	...
MSB 42	......	19.1	+55 26	79	- 4	(9.5)	....	...	R8	.	.	-34 d	...

......	220870	$23^h22^m.2$	+48°58'	77°	-11°	9.7	....	...	N	7	2	-18 c	...
ST And	222241	33.8	+35 13	75	-25	8.3	12.4	335	R3e	2	2	+32 c	+13
19 Psc	223075	41.3	+ 2 56	63	-56	5.3	....	...	N	7	3	+11 a	...
......	223392	44.0	+ 5 50	66	-53	8.8	....	...	R3	•	•	-25 a	...
MSB 75	......	54.0	+56 25	84	- 5	(10.2)	....	...	Ne	7	2	-46 b	-78
WZ Cas	224855	56.2	+59 48	85	- 2	6.9	8.5	193	N	9	1	-34 a	...
......	224959	57.0	- 3 23	63	-64	9.9	....	...	RO	•	•	-132 c	...
SU And	225217	59.4	+43 0	82	-18	7.9	8.5	...	N	4	3	- 6 b	...

NOTES TO TABLE 1

HD 20234. Lick Obs. Pub., 18, 23, 1932.
HD 31996. R Lep. Velocity may vary slightly with phase.
HD 34842. UV Aur. Emission lines of [O III], Mg I, Fe I, and H have been observed near minimum. Absorption-line velocity may vary slightly with phase.
HD 38218. TU Tau. Spectrum is composite with A-type predominating in the violet, N-type in the visual region.
5^h 56.9m. XZ Aur. See Allen and Edwards, M.N., 101, 295, 1941.
6^h 51.7m. +6°1451. Harv. Announcement Card 616, 1942.
7^h 7.0m. Harv. Bull. 837, 1926.
HD 56167. RU Cam. Velocity-curve. Mt. W. Contr., No. 372; Ap. J., 68, 408, 1928.
HD 95405. Class K5R.
HD 107957. S Cen. Lick Obs. Pub., 18, 100, 1932.
HD 108683. Velocity had wrong sign in Mt. W. Contr., No. 525; Ap. J., 82, 202, 1935.
HD 134453. X TrA. Lick Obs. Pub., 18, 119, 1932.
17^h 17.0m. -36°11460. Harv. Circ. 224, 1921.
18^h 8.1m. Harv. Circ. 231, 1922.
19^h 3.8m. SV Sge. Harv. Bull. 837, 1926.
19^h 35.4m. Harv. Bull. 837, 1926.
19^h 58.6m. MSB 37. Lick Obs. Bull., 18, 48, 1937. See Area C4, star 28.
HD 193368. WX Cyg. λ6707 Li I nearly as strong as in WZ Cas.
HD 193680. U Cyg. Spectrum and radial velocity change with light-phase.
HD 202874. Lick Obs. Pub., 18, 176, 1932.
HD 209890. RZ Peg. Velocity may vary slightly.
HD 224855. WZ Cas. Has strongest known λ6707 Li I. Keenan and Morgan classify as the coolest carbon-band star. No star is known to have stronger D lines.

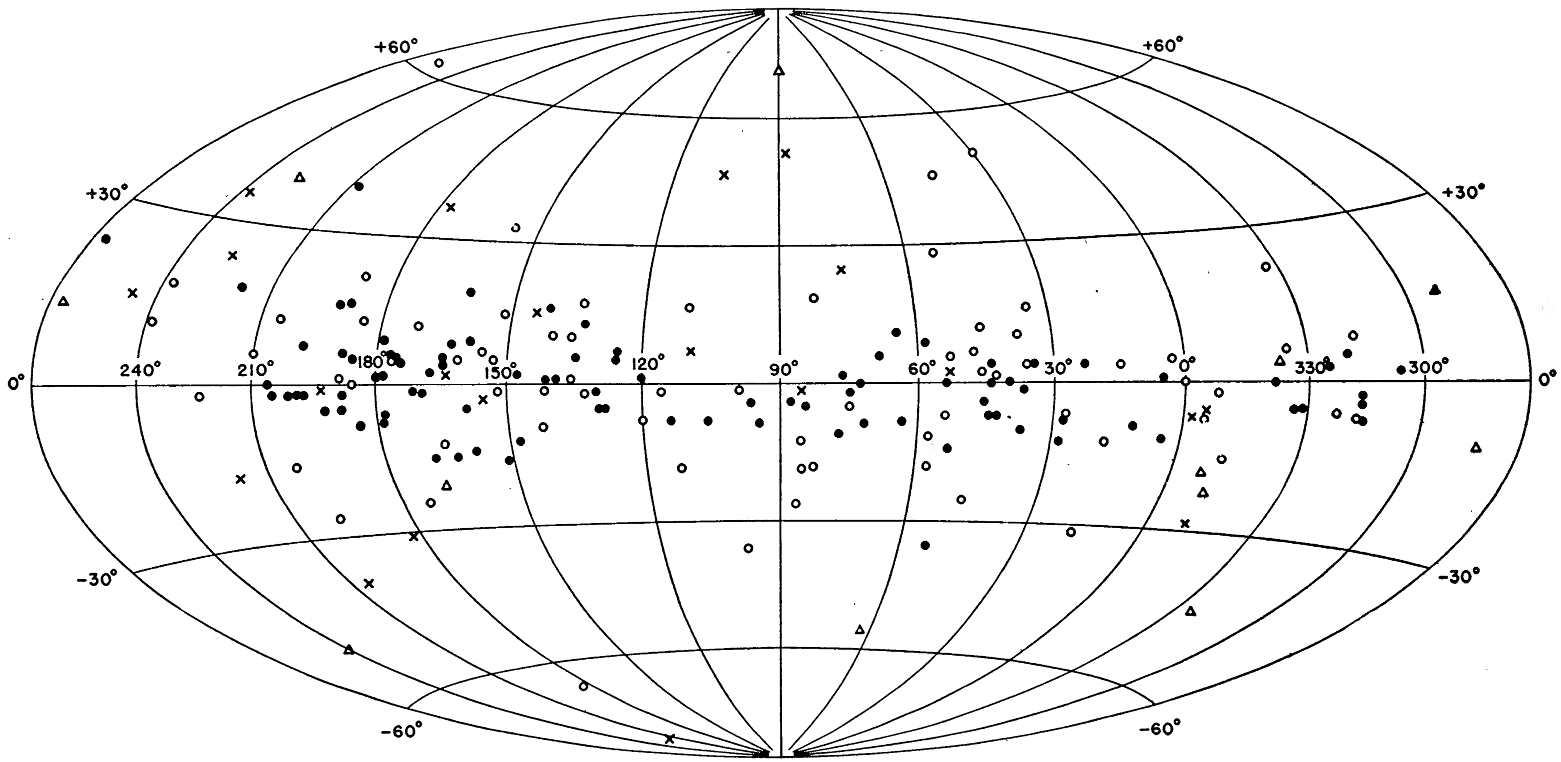

FIG. 1.—Class-N stars plotted in galactic co-ordinates. Triangles represent stars brighter than $6^{m}.0$, visual magnitude; crosses, $6^{m}.0$–$6^{m}.9$, inclusive; circles, $7^{m}.0$–$8^{m}.9$; and dots, $9^{m}.0$ or fainter. For variable stars, the magnitude at maximum is used. Photographic magnitudes have been converted to visual by applying a color index of $3^{m}.0$.

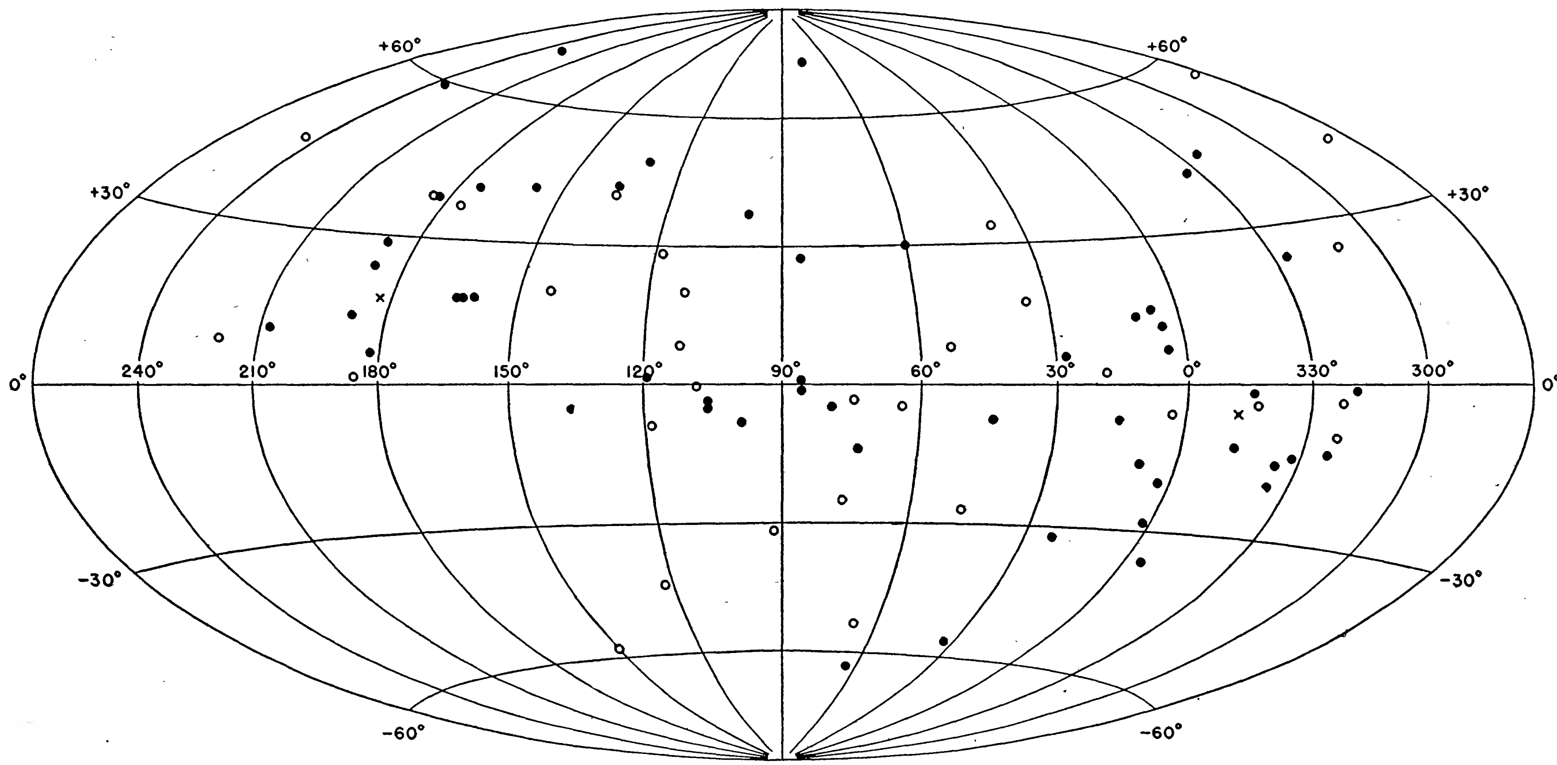

FIG. 2.—Class-R stars plotted in galactic co-ordinates, with circles for stars brighter than visual magnitude 9.0 and dots for those fainter

Within 30° of the galactic plane there are 171 stars of class N whose velocities can be studied for evidence of galactic rotation. Only HD 189711 was omitted on account of its outstandingly large velocity. These velocities, freed from solar motion (apex α 270°, δ +28°, and $V_0 = 20$ km/sec), have been gathered into thirteen velocity means (Table 2). The last column shows the mean radial velocity freed from solar motion and reduced to mean apparent visual magnitude 8.3. The effect of differential galactic rotation is evident from the plot of the data of Table 2 in Figure 3.

TABLE 2

NORMAL VELOCITIES—CLASS N

No. of Stars	$\bar{m}_v$	$\bar{l}$	$\bar{b}$	$\bar{\rho}$
13	7.5	358°	−9°	+17.4 km/sec
11	8.9	32	0	+17.8
20	8.3	49	−1	+12.0
10	9.0	72	+1	− 5.7
11	8.2	88	−7	−24.7
8	8.3	113	−2	−20.0
13	9.2	132	+4	+ 4.0
16	8.5	150	0	+ 5.4
24	8.9	170	0	+13.0
18	8.5	190	0	+19.1
13	7.9	218	+5	+ 8.4
8	7.8	295	+5	−11.3
10	7.8	328	+2	+ 3.8

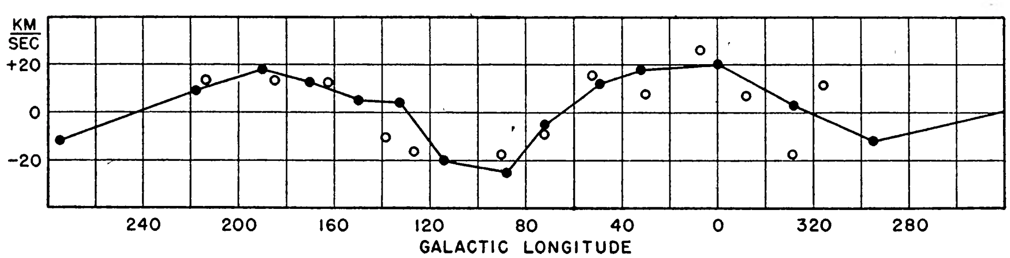

FIG. 3.—The mean velocities of class-N stars in Table 3 are plotted as dots and connected with straight lines. The mean velocities of class-R stars in Table 4 are plotted as circles; they have been corrected for K and dV (p. 159) and reduced to visual magnitude 9.8 (general absorption included).

The mean distance, $\bar{r}$, for class-N stars of magnitude 8.3 has been derived from the data of Table 2 by a least-squares solution of the conditional equation for differential galactic rotation:

$$\bar{r}A \sin 2(\bar{l} - l_0) \cos^2 \bar{b} = \bar{\rho} ,$$

wherein $A = 17.7$ km/sec/kiloparsec, $l_0 = 325°$, and $\bar{l}$ and $\bar{\rho}$ are from Table 2. The values of $\bar{b}$ in the fourth column differ so little from zero that $\cos^2 \bar{b}$ was assumed to be unity. The mean distance found for class-N stars of apparent visual magnitude 8.3 is 1.10 ± 0.08 kiloparsecs. The evaluation of the mean absolute magnitude depends to some extent upon what value is adopted for general absorption per kiloparsec. If 0.35 visual magnitude is assumed, the mean absolute visual magnitude becomes −2.3 ± 0.2. This may be compared with −1.88 derived by R. E. Wilson[12] from proper motions and the radial velocities of the earlier catalogue.

Table 3 gives thirteen mean velocities derived from 62 stars of class R in the same way as the data for class N in Table 2. HD 187216 and HD 209621 were omitted because of their large velocities. $\bar{\rho}$ is for mean apparent visual magnitude 9.0. Inspection shows evidence of differential galactic rotation, but a lack of symmetry with respect to the axis of zero velocity suggested including the well-known K-term and a correction to V_0, the

TABLE 3

NORMAL VELOCITIES—CLASS R

No. of Stars	$\bar{m}$	$\bar{l}$	$\bar{b}$	$\bar{\rho}$
10	9.9	7°	− 3°	+14.1 km/sec
4	8.8	30	+ 6	+ 2.8
3	9.4	52	+10	+ 7.4
6	8.8	73	−10	− 7.7
3	9.5	90	− 3	−14.0
7	8.5	127	+ 6	−14.3
3	9.6	139	0	−11.0
3	9.3	163	+18	+ 2.6
6	9.2	185	+15	+ 4.3
2	8.4	214	+10	+ 2.6
2	8.4	315	+12	+ 3.9
7	9.4	329	− 8	−13.7
6	8.4	348	−12	+ 2.9

adopted solar motion, in making the solution for differential galactic rotation. A conditional equation of the form

$$K + dV \cos (\bar{l} - 20°) + \bar{r}A \sin 2(\bar{l} - l_0) = \bar{\rho}$$

was used ($\bar{b}$ assumed to be 0). Least-squares solution gave

$$K = -3.5 \pm 1.3 \text{ km/sec},$$
$$dV = +1.9 \pm 1.6 \text{ km/sec},$$
$$\bar{r} = 0.67 \pm 0.10 \text{ kiloparsecs}.$$

This mean distance is for a mean apparent visual magnitude 9.0. Absolute visual magnitude −0.4 ± 0.4 for class-R stars follows from the above mean distance and mean magnitude, if we use a general absorption of 0.35 mag. per kiloparsec. Wilson's[13] value is $\bar{M} = -0.50 \pm 0.20$.

The value of K might be interpreted as evidence of a systematic error in the velocities if it were not that intercomparison of velocities from spectrograms of high and low dispersion has shown no such error. No obvious explanation is at hand.

The value dV is only slightly larger than its probable error; hence, the use of a value differing significantly from the +20 km/sec actually applied for solar motion receives scant justification.

The values of $\bar{\rho}$ in Table 3 have been corrected for K and dV, derived above, and then made to correspond to a mean visual magnitude of 9.8 (corrected for general absorption).

[12] *Mt. W. Contr.*, No. 631; *Ap. J.*, **92**, 188, 1940.

[13] *Mt. W. Contr.*, No. 618; *Ap. J.*, **90**, 492, 1939.

The resultant values for $\bar{\rho}$, plotted as circles in Figure 3, are in fair accord with the values for class-N stars of mean visual magnitude 7.9 (8.3 uncorrected). This should be true, since class-R stars, which are fainter than class-N stars by the difference of their absolute magnitudes (1.9), should be at the same distance and therefore give similar curves for differential galactic rotation.

Table 4 contains those stars whose velocities after correction for solar motion are numerically larger than 100 km/sec.

TABLE 4

STARS OF HIGH VELOCITY

Star	*m*	Spect.	Vel. from Abs. Lines	*l*	*b*
HD 5223*	8.8	R3	−228 km/sec	91°	−32°
HD 13826*	8.3–9.0	R0	−163	122	−44
Lee 107	11.3	R5	−137	229	+71
HD 112869*	9.2–9.6	R6p	−135	74	+79
HD 187216	9.6	R3	−129	85	+27
HD 189711	8.7	N1	−167	17	−12
HD 209621*	8.8	R3	−379	47	−27
HD 224959	9.9	R0	−132	63	−64

TABLE 5*

INTERSTELLAR D LINES

Star	*m*	Spect.	Interstellar Velocity	Equiv. Width 0.5(D2+D1)	*M*
HD 5223	8.8	R3	0 km/sec	0.15 A	+2.2
13826†	Var.	R0	− 3	.49	−1.7
137613	7.4	R0	− 5	.28	−1.0
177336‡	Var.	N	−14	.28	−1.9
189711	8.7	N	−10	.56	−1.7
209621	8.8	R3	−10	0.27	+0.4

* Part of the data of this table appears in *Pub. A.S.P.*, **54**, 257, 1942.
† V Ari: mag 8.3–9.0.
‡ V Aql: mag 6.7–8.2.

Keenan and Morgan[14] have noted that the four stars marked with asterisks in Table 4 are characterized by very strong g-bands and weak atomic lines in the blue region. Lee 107, HD 187216, and HD 224959 are similarly characterized. All seven have large negative velocities. It may be worth noting that one of these stars (HD 5223) has the largest proper motion known for any star of class R or N. This suggests that this group of stars may be of lower absolute magnitude than the average class-R star.

Interstellar sodium lines.—Four class-R and two class-N stars have velocities large enough to permit the interstellar D lines to be separated from the stellar D lines. It has been possible to derive both the interstellar velocities and the total absorption of the interstellar D lines from the coudé spectrograms (Table 5). The values for 0.5 (D2 + D1)

[14] *Ap. J.*, **94**, 509, 1941.

have been used to read off distances for the stars of Table 5 by the curve of equivalent width versus distance given by P. W. Merrill for class-B stars.[15]

The absolute magnitude of HD 5223 from the interstellar D lines is +2.2, noteworthy as much fainter than the magnitudes obtained for the other stars of the table. This is

TABLE 6

ABSOLUTE MAGNITUDES

Method	Authority	Class R	Class N
Proper motions and radial velocities (*Contr*. 525)	R. E. Wilson	−0.5	−1.9
Radial velocities (Table 1)	R. F. Sanford	−0.4	−2.3
Total absorption of interstellar D lines	R. F. Sanford	−0.8 (0.0)	−1.8

quite consistent with this star's abnormally large proper motion, already alluded to. The mean of the absolute magnitudes of the four class-R stars is 0.0, or −0.8 if HD 5223 is omitted. The two class-N stars give a mean absolute magnitude of −1.8.

Absolute magnitudes for stars of classes R and N by three independent methods are brought together in Table 6. The class-N stars are unquestionably more than a magnitude brighter than class-R stars.

[15] *Mt. W. Contr*., No. 569; *Ap. J*., **86**, 35, 1937.