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

By ROSCOE F. SANFORD

ABSTRACT

The catalogue.—An attempt is made to bring together in Table I all the radial velocities of the stars whose spectra show the bands of carbon. Those of class N have been reduced to a velocity system which harmonizes laboratory and stellar data.

Velocities from emission lines.—Twenty stars of class N having emission lines of hydrogen give -21.6 km/sec. for the mean difference between the radial velocities depending upon them and those from the absorption features. These stars are all variable with a mean period of 407 days and a mean range of 4 mag. Emission lines of hydrogen are usually associated with stars having a large magnitude range, and in such stars as fail to show them the explanation may be that the observations occur at the wrong phase, since the intensity of emission is known to fall to zero at certain phases. Moreover, the presence of emission in the spectrum of a star not known to vary should cause it to be suspected of variability.

Solar motion, galactic rotation, and absolute magnitude.—A least-squares solution based upon all the material for the class-N stars gives a solar motion quite similar to that for the naked-eye stars, a galactic rotation term of 13.4 km/sec., a mean distance of 0.727 kiloparsecs, a mean absolute magnitude of -1.4, and 315° as the longitude of the galactic center.

The reality of the galactic rotation term is strengthened by dividing the stars into three groups, whose mean apparent magnitudes are 6.5, 8.1, and 9.3, and solving these groups for galactic rotation alone after the elimination of the solar motion. The three results are 7.2, 16.3, and 22.4 km/sec.—a quite consistently progressive increase.

Mean absolute magnitudes for the three groups are computed on the basis of their mean apparent magnitudes and mean distances. These latter can be obtained from the constant for the increase of the galactic-rotation term per kiloparsec as obtained from the investigations of stars of class B and of Cepheid variables. Using the constant obtained by Joy for the latter stars, the values of the absolute magnitude are -1.4, -1.5, and -1.1, respectively. The constant for the B stars gives absolute magnitudes 0.4 brighter.

Heretofore the radial velocities of stars of spectral classes R and N were to be found only in the following lists: 8 N stars by Hale, Ellerman, and Parkhurst,[1] 10 R stars by W. C. Rufus,[2] 25 of class N by J. H. Moore,[3] and 30 of class R by R. F. Sanford.[4]

Immediately following the completion of the last list a program for the radial velocities of stars of class N was started by the writer

* *Contributions from the Mount Wilson Observatory, Carnegie Institution of Washington*, No. 525.

[1] *Pub. Yerkes Obs.*, **2**, 341, 1903.

[2] *Pub. Detroit Obs.*, **2**, 135, 1916.

[3] *Lick Obs. Bull.*, **10**, 160–168, 1922.

[4] *Mt. W. Contr.*, No. 276; *Ap. J.*, **59**, 339, 1924.

with the idea of increasing as far as possible the number obtained by Moore, an increase which would have been rather moderate if both the plates available and the spectrographic equipment had not in the meantime undergone marked improvement. With only a few exceptions, the spectrograms used in this investigation were obtained with the stellar plane-grating spectrograph designed by Merrill and described[5] by him in *Mount Wilson Contribution* No. 432. Suitable spectrograms of stars of spectral class N as faint as visual magnitude $8\frac{1}{2}$ may under good conditions be obtained in the red with exposures of the order of two hours by using ammoniated Eastman 3C plates.

It thus became possible to photograph even more than had been anticipated of the stars of class N from the *Henry Draper Catalogue*. In addition, a considerable number of spectrograms was obtained for the purpose of checking the classification of discoveries[6] of this spectral class upon objective-prism spectra photographed at Mount Wilson with the 10-inch telescope. Most of these latter stars were of the ninth visual magnitude or fainter and necessitated the use of a short-focus camera with a resultant dispersion of 110 A per millimeter. Some of the other faint stars were also photographed in this manner. Otherwise, for the most part, a camera of 10-inch focus, with a dispersion of 65 A per millimeter, was employed. A dispersion of 33 A per millimeter was obtained by using an 18-inch camera for a few stars. Some exposures of exceptionally high dispersion were made with various coudé spectrographs. Such a spectrogram of Y Canum Venaticorum made with a concave-grating spectrograph has a dispersion of approximately 3.5 A per millimeter.

In the spectra of stars of this class, the identification of the complex absorption features has never been entirely satisfactory. The Swann, cyanogen, and hydrocarbon bands and certain very conspicuous lines such as those of sodium are well known. But a large percentage of the details, notably those extending into the visual region which Shane[7] measured, remained unidentified.

At first, therefore, it was decided to use Moore's results as a basis for the velocities of standards for the Hartmann spectrocomparator

[5] *Ap. J.*, **74**, 188–200, 1931.

[6] *Pub. A.S.P.*, **45**, 306–308, 1933.

[7] *Lick Obs. Bull.*, **10**, 79–92, 1920.

and for the wave-lengths to be used for micrometer measurement—a practice followed until a large number of spectrograms had been obtained with the grating spectrograph. During this time these wave-lengths were improved, and some features adopted at first were rejected as not being generally useful.

The region measured on the grating spectrograms includes the D lines, which, when suitably exposed, offered an opportunity of comparison with the wave-length system employed. Twenty-one spectrograms were selected, each of which furnished a good determination of the radial velocity, both from the D lines, by using solar wave-lengths, and from other tabular features. The differences were remarkably consistent and significantly large, the sodium lines giving algebraically smaller radial velocities. Further checks seemed desirable.

A good opportunity was offered when Merrill[8] found that in the far red the spectra of stars of class N could be largely accounted for by the details of the cyanogen band spectrum, and when, at his suggestion, I looked for and found the same to be true in the red region.

An intercomparison of spectra of class-N stars and King's furnace spectra resulted in the identification of many features for which accurate wave-lengths could be measured on the laboratory spectrograms. A new set of wave-lengths was thus obtained which included the features already used. Radial velocities were then computed on the basis of the old tabular wave-lengths as well as on that of the new wave-lengths of these same features and also on the basis of the additional features measured. The three comparisons are given below together with their mean:

D lines − old tables	−5 km/sec.
Revised λλ − old λλ (same features)	8
New lines − old lines (old λλ)	−9
Mean	−7

Hence velocities based upon the old tables need to be decreased by 7 km to conform to the new system.

This correction is significantly like the K term which Moore obtained from his solution for the solar motion. He was of course well

[8] *Mt. W. Contr.*, No. 486; *Ap. J.*, **79**, 202, 1933.

aware of the fact that this K term would have largely disappeared had he not applied a systematic correction to the velocities from low-dispersion spectrograms. He concluded to use this correction, however, since its necessity was indicated by such intercomparisons as were possible, although he was frank to point out some of their unavoidable deficiencies. His radial velocities, corrected by −7 km/sec., may be compared with the writer's in twenty-one cases. Since three of these intercomparisons involve low weight in one case or the other, eighteen well-determined values remain common to both lists. The mean of their differences is practically zero.

It may also be remarked that the mean of the differences between the velocities of the eight class-N stars given by Hale, Ellerman, and Parkhurst and their velocities determined at Mount Wilson is −4 km/sec.

Table I includes all the velocities of stars of class N obtained at Mount Wilson; of those few below our declination limit obtained by the D. O. Mills expedition, at Santiago, Chile, and appearing in Moore's list; and of some miscellaneous stars originally suspected of belonging to this spectral class. The velocities of stars of spectral Class R as given in *Contribution* No. 276[4] are included, together with a few observed later. Table I should therefore contain a complete list of the known radial velocities of stars in whose spectra the bands of carbon appear.

The class-N stars from the *Henry Draper Catalogue* within reach of Mount Wilson and not yet observed for radial velocity are as follows: HD 44653, 46321, 47396, 48664, 52225, 57160, 57884, 58195, 58385, 60952, 172804, 190606, 191783, 195665. To these should be added three stars from the Mount Wilson list,[6] Nos. 26, 27, and 32. Practically all have visual apparent magnitudes 9 or fainter.

Among the class-R stars there remain likewise the following from the *Henry Draper Catalogue:* HD 27108, 63130, 70138, 78278, 163838, 166097, 166129, 170282, 171399, 179355, 187216, 188934, 215673, 216649, 218851. No magnitudes are given for six of these, while the mean apparent visual magnitude for the remainder is 10.4, which accounts for the lack of observations.

The *Henry Draper Catalogue* has, in large part, furnished its number, the BD designation, the co-ordinates for 1900, the magnitudes, and the types for Table I. Additional information on the mag-

TABLE I*

RADIAL VELOCITIES OF STARS OF CLASSES N AND R

	HD No.	Designation	1900 α	1900 δ	Magnitude Max.	Magnitude Min.	Type	Vel. Km/Sec. Abs.	Vel. Km/Sec. Em.	Galactic l	Galactic b	Notes	Period
													days
1	1306	ST Cas	0h12m2	+49°44′	7.5	9.0	Nb	− 43	......	85°	−12°	(33)	....
2	1546	VX And	14.6	+44 9	8.1	9.5	NcN7	+ 8 *a*	......	85	−18	(27)	....
3	1994	BD+53°66	19.1	+53 44	9.7	....	R5R5	− 36 *c*	......	86	− 8	(1)	....
4	2342	AQ And	22.2	+35 2	7.8	8.0	Nb	− 7 *d*	......	86	−27	....	....
5	5223	BD+23°123	48.9	+23 32	8.8	....	R3	−234 *b*	......	91	−32	(1)	....
6	7561	Z Psc	1 10.6	+25 14	7.4	8.1	NaNo	+ 22 *b*	......	98	−36	(20)	....
7	8879	R Scl	22.4	−33 4	6.2	8.8	Np	− 8 *c*	......	211	−80	(20)..	376
8	....	WW Cas	27.1	+57 14	9.1	11.7	(N1)	− 58 *e*	......	96	− 4	(2)(32)	....
9	10636	BD+53°379	38.7	+53 28	9.9	....	R5	− 33 *e*	......	99	− 8	....	....
10	....	X Cas	49.8	+58 46	8.4	13.1	(N1e)	− 57 *c*	−80	99	− 1	....	425
11	13826	V Ari	2 9.6	+11 47	8.3	9.0	NbR8	−183 *b*	......	122	−44	(21)	....
12	....	MSB 2	20.1	+51 37	....	....	(N3)	− 54 *e*	......	105	− 8	(2)	....
13	16115	BD−10°513	30.2	− 9 53	8.3	....	R3R3	+ 11 *b*	......	150	−58	(1)	....
14	16326	UY And	32.1	+38 44	*11.0*	*14.0*	N	− 58 *e*	......	113	−18	....	....
15	19557	BD+57°702	3 3.7	+57 31	8.1	....	R5R5	− 6 *a*	......	108	0	(1)	....
16	19881	BD+47°783	6.7	+47 27	9.2	....	Np	+ 10 *e*	......	114	− 8	....	....
17	20234	CD−57°513	10.0	−57 41	5.7	....	Na	+ 14	......	240	−50	(3)	....
18	21280	Y Per	20.9	+43 50	8.3	11.0	Nbe	− 4 *c*	−14	118	− 9	....	254
19	22611	U Cam	33.2	+62 19	6.9	9.0	NbN5	− 3 *c*	......	109	+ 7	....	419
20	....	BD+51°762	33.9	+51 2	8.9	....	(N2)	+ 6 *c*	......	115	− 2	(2)	....
21	....	AC Per	38.1	+44 28	*10.2*	*12.3*	(N3)	− 33 *e*	......	120	− 7	(2)(20)	....
22	....	MSB 5	41.5	+52 54	....	....	S	− 82 *e*	......	115	0	(2)(34)	....

* The small letters following the velocities represent the possible uncertainties in each from the writer's estimates based upon a consideration of the probable errors, the number of spectrograms, and their quality and dispersion. They may be interpreted as follows: (*a*) Three or more spectrograms; uncertainty of 1 km/sec. possible. (*b*) Three or more spectrograms; uncertainty of 2–3 km/sec. possible. (*c*) Only two spectrograms; uncertainty of 1–3 km/sec. indicated. (*d*) Only two spectrograms; uncertainty of 3–5 km/sec. indicated. (*e*) All cases in which the probable error exceeds 5 km/sec. and those in which the velocity depends on a single spectrogram.

23	25408	BD+61°667	3h 57m.2	+61°32′	7.9	....	R8R8	− 10 *b*	......	111°	+ 8°	(1)	....
24	....	SY Per	4 8.9	+50 23	9.5	12.5	(N3)	0 *e*	......	120	1	(2)(25)	476
25	....	MSB 7	13.0	+40 53	.....	....	(N3)	− 2 *e*	......	128	− 5	(2)	....
26	....	MSB 8	22.9	+39 38	.....	....	(N1)	+ 13 *e*	......	129	− 5	(2)	....
27	....	AV Per	32.6	+41 26	*13.5*	*15.0*	(N1)	+ 41 *e*	......	130	− 2	(2)	....
28	30243	ST Cam	40.8	+67 59	7.0	8.3	Nb	− 23 *e*	......	110	+16	....	....
29	30443	BD+34°911	42.7	+34 49	9.0	....	Nb	+ 76 *e*	......	136	− 5	....	....
30	30533	T Cae	43.8	−36 23	*8.7*	*10.3*	Nb	− 7	......	205	−39	(31)	....
31	30710	BD+15°691	44.9	+15 37	10.1	....	Na	+ 38 *c*	......	151	−16	....	....
32	30755	TT Tau	45.2	+28 21	8.1	8.8	NbN3	+ 20 *c*	......	142	− 9	....	166
33	....	BD+38°955	45.7	+38 20	8.8	....	(No)	+ 24 *c*	......	133	− 2	(2)(20)	....
34	....	MSB 11	46.8	+49 46	.....	....	(Noe)	+ 4 *c*	− 22	125	+ 5	(2)(30)	....
35	31996	R Lep	55.0	−14 57	6.1	9.7	PecN6e	+ 32	− 1	182	−31	(5)(21)	440
36	32088	BD+50°1112	55.6	+50 29	9.0	....	Nb	− 12 *e*	......	125	7	....	....
37	32736	W Ori	5 0.2	+ 1 2	5.9	7.7	NbN5	+ 16 *a*	......	167	−21	....	200
38	33016	TX Aur	2.2	+38 52	8.5	9.2	Nb	− 6 *c*	......	135	+ 1	....	330?
39	33404	BD−5°1174	4.9	− 5 38	8.6	....	NbNo	+ 23 *e*	......	173	−24	(32)	....
40	34467	BD+35°1046	12.5	+35 41	9.1	....	Nb	− 2 *e*	......	139	+ 1	(32)	....
41	34842	UV Aur	15.3	+32 24	7.9	10.1	Se	....	− 15	142	− 1	(11)	350
42	35556	S Aur	20.5	+34 4	9.3	12	Nb	+ 3 *d*	......	141	+ 1	(25)	591
43	36602	RT Ori	27.8	+ 7 4	7.5	8.5	Nb	+ 5 *c*	......	165	−12	....	....
44	36972	S Cam	30.2	+68 45	7.8	10.8	R8eNp	− 13 *e*	− 17	111	+20	....	311
45	37212	CD−25°2539	31.7	−25 48	7.9	....	Na	+ 40 *b*	......	197	−26	....	....
46	38218	TU Tau	39.1	+24 23	8.7	9.5	NbN2	− 24 *c*	......	152	− 1	(35)	....
47	38307	Y Tau	39.7	+20 39	6.9	8.9	NbN2	− 17 *c*	......	155	− 3	....	240
48	....	BD+15°921	39.7	+15 28	9.5	....	(No)	+ 22 *e*	......	159	− 5	(2)	....
49	38521	AF Aur	41.4	+44 50	8.5	9.5	Pec	− 11 *e*	......	134	+10	(2)	....
50	38572	BD+30°1014	41.7	+30 36	9.0	9.3	NaNo	+ 18 *e*	......	147	+ 2	(20)(32)	....
51	....	Mayall's Var.	54.2	+39 42	.....	....	(Noe)	+ 80 *a*	+ 69	140	+10	(2)(20)(28)	416
52	42272	TU Gem	6 4.7	+26 3	7.4	8.3	NaN3	+ 48 *c*	......	153	+ 5	(20)	....
53	....	BD−0°1246	12.7	− 0 12	9.5	....	(No)	+ 34 *e*	......	177	− 6	(2)	....
54	....	MSB 17	13.4	− 1 7	.....	....	(N3)	+ 80 *e*	......	179	− 7	(2)	....
55	44388	V Aur	16.5	+47 45	8.3	<12.2	Nbe	+ 6 *e*	+ 3	134	+17	....	357
56	....	MSB 18	16.5	+ 7 21	.....	....	(N2)	+ 28 *e*	......	171	− 2	(2)	....
57	....	BD−7°1402	18.5	− 7 25	9.5	....	(N)	+ 46 *e*	......	184	− 8	(2)(23)	....

TABLE I—*Continued*

	HD No.	Designation	1900 α	1900 δ	Magnitude Max.	Magnitude Min.	Type	Vel. Km/Sec. Abs.	Vel. Km/Sec. Em.	Galactic l	Galactic b	Notes	Period
													days
58	44984	BL Ori	$6^h19^m.8$	$+14°48'$	6.6	....	Nb	+13 *c*	.....	164°	+2°	74 Schj	....
59	45087	AB Gem	20.3	+19 8	.....	....	(N3)	+7 *d*	.....	161	+5	(2)	....
60	....	CD−26°2983	20.5	−27 1	8.6	....	N	+23 *e*	.....	202	−16	(2)	....
61	....	BD+12°1177	25.3	+12 33	9.4	....	(N2)	−14 *e*	.....	167	+3	(2)	....
62	46687	UU Aur	29.7	+38 31	6.2	6.7	NaN3	+11 *a*	.....	144	+15	78 Schj	....
63	47883	VW Gem	35.7	+31 33	8.6	8.8	Na	+14 *c*	.....	151	+14	....	....
64	50436	BD−4°1708	48.2	−4 27	*9.2*	*10.4*	Nb	+38 *d*	.....	185	0	....	....
65	50949	UW Aur	50.3	+41 14	*9.6*	*12.6*	(N3)	0 *e*	.....	143	+20	....	530
66	51208	CD−42°2818	51.3	−42 14	6.0	....	Na	+32 *e*	.....	219	−17	(20)	....
67	....	BD+6°1451	51.7	+6 29	9.5	....	(N3)	+57 *e*	.....	176	+6	(2)	....
68	51620	RV Mon	53.0	+6 18	7.0	8.2	Nb	+16 *b*	.....	176	+6	....	....
69	52432	BD−3°1685	56.1	−3 6	7.5	....	R5	+24 *c*	.....	185	+2	(1)(12)	....
70	....	RY Mon	7 2.1	−7 24	7.7	9.1	(N5)	+2 *c*	.....	189	+1	(2)	....
71	54361	W CMa	3.4	−11 46	6.9	7.5	Na	+21 *d*	.....	193	−1	....	....
72	55284	V Gem	7.2	+14 46	*10.8*	*14.9*	Rpe	+53 *d*	+42	171	+12	(1)(13)	....
73	....	BD+5°1606	10.3	+5 14	9.5	....	(N3)	+56 *e*	.....	179	+9	(2)(23)	....
74	56167	RU Cam	10.9	+69 52	7.9	9.0	KoRo	−24	.....	118	+29	(6)	22.17
75	58337	BD+22°1679	20.1	+22 7	10.0	....	R5R3	+4 *e*	.....	164	+18	....	....
76	58364	BD+22°1680	20.2	+22 5	9.8	....	R5R3	−3 *c*	.....	164	+18	....	....
77	59643	BD+24°1684	25.8	+24 44	8.2	....	R8R9	+43 *e*	.....	161	+18	(1)	....
78	60826	BD+2°1715	31.3	+2 18	8.7	9.1	Na	+40 *e*	.....	184	+13	....	....
79	63353	W CMi	43.4	+5 40	*9.8*	*11.3*	R8	+25 *e*	.....	182	+17	....	....
80	....	MSB 31	45.0	−0 38	.....	....	(N3)	0 *e*	.....	189	+14	(2)(18)	....
81	....	MSB 33	57.5	−1 51	.....	....	(N6)	+26 *e*	.....	191	+16	(2)	....
82	67190	RT Pup	8 1.7	−38 29	*9.3*	*10.2*	Nb	+28 *d*	.....	222	−3	....	....
83	67507	RU Pup	3.2	−22 37	*9.4*	*11.6*	Nb	+23 *e*	.....	210	+6	....	....
84	70072	RY Hya	14.9	+3 5	8.3	9.6	Nbe	+17 *c*	−8	189	+22	(23)	535

85	....	T Lyn	8^h16^m4	+33°50′	8.0	12.0	(Noe)	+ 5 *c*	− 9	156°	+34°	(20)	416
86	75021	CD−29°6735	42.4	−29 21	7.6	....	R8R7	+ 13 *b*	.....	220	+ 9	(1)	....
87	76221	X Can	49.7	+17 37	6.1	6.6	NbN3	− 2 *c*	.....	178	+37	115 Schj	130
88	76396	BD+51°1462	50.8	+51 49	8.8	....	R5	− 52 *e*	.....	134	+41	....	....
89	....	T Can	51.0	+20 14	8.0	10.2	NN3	+ 4 *c*	.....	175	+37	(23)	500
90	76846	BD+34°1929	53.6	+34 9	9.2	....	Ro	+ 26 *e*	.....	157	+42	(1)	....
91	77234	BD+50°1603	56.2	+50 29	9.5	....	R5R5	+ 5 *a*	.....	135	+43	(1)	....
92	79319	BD+14°2048	9 8.3	+14 37	8.9	....	R5R4	+ 1 *e*	.....	184	+39	(1)	....
93	85319	W Sex	45.9	− 1 33	10.3	12.3	Nbe	+ 63 *c*	+ 28	208	+39	....	....
94	85405	Y Hya	46.4	−22 32	6.5	8.0	NpN3	+ 7 *c*	.....	226	+24	....	80?
95	86111	X Vel	51.3	−41 7	*9.5*	*11.8*	Nb	− 7 *e*	.....	239	+11	(31)	....
96	88539	CD−34°6528	10 7.5	−34 50	7.0	....	Na	+ 4 *b*	.....	238	+18	....	....
97	91793	U Ant	30.8	−39 3	*8.3*	*9.3*	Nb	+ 37 *c*	.....	244	+16	....	168?
98	92055	U Hya	32.6	−12 52	4.5	6.3	NbN2	− 27 *b*	.....	229	+39	132 Schj	....
99	92839	BD+68°617	38.1	+67 56	6.3	....	Na	− 18 *e*	.....	106	+46	(14) 318 Birm	....
100	....	V Hya	46.8	−20 43	6.7	12.0	(N6)	− 13 *b*	.....	237	+35	(20)	527
101	95405	....	55.7	−25 19	9.0	....	Kp	+ 12 *e*	.....	242	+31	(15)	....
102	100764	BD−13°3407	11 30.7	−14 2	8.7	....	Ro	+ 5 *b*	.....	246	+45	(1)	....
103	107957	S Cen	12 19.2	−48 53	*8.1*	*9.5*	Nbp	− 41	.....	266	+13	(3)	....
104	108105	SS Vir	20.1	+ 1 20	7.2	9.0	PecNp	+ 6 *c*	.....	259	+63	(36)	....
105	108683	CD−37°7905	24.0	−37 42	9.3	....	(No)	+ 46 *e*	.....	266	+24	....	....
106	110914	Y CVn	40.4	+45 58	4.8	6.0	NbN3	+ 12 *a*	.....	90	+72	152 Schj	....
107	111166	RU Vir	42.2	+ 4 42	8	12.6	R3ep	− 1 *b*	− 18	271	+66	....	439
108	112559	RY Dra	52.5	+66 32	6.1	7.1	N4p	− 20 *d*	.....	88	+51	....	....
109	112869	BD+38°2389	54.7	+38 20	9.2	9.6	NbR6p	−128 *d*	.....	74	+79	(23)	....
110	113801	BD−19°3634	13 1.1	−19 31	8.7	....	K5R	− 8 *e*	.....	276	+42	....	....
111	128033	Z Lup	14 29.5	−42 56	*8.2*	*9.6*	Na	+ 14 *c*	.....	290	+15	....	....
112	133332	BD−2°3939	58.8	− 2 28	10.6	....	R5	− 28 *e*	.....	323	+45	(1)	....
113	134453	X TrA	15 4.8	−69 42	*8.2*	*10.0*	Nb	− 4 *e*	.....	282	−11	(3)	....
114	137613	CD−24°12084	21.9	−24 49	7.4	....	RoR3	+ 57 *b*	.....	310	+25	(1)(23)	....
115	141826	V CrB	45.9	+39 52	7.2	12.0	Nb2	−115 *e*	−139	30	+50	....	357
116	144578	RR Her	16 1.5	+50 46	7.8	9.5	K5ep	− 46 *e*	− 39	46	+46	(8)	242
117	145777	BD−14°4371	7.6	−14 57	10.7	....	Ro	+ 18 *e*	.....	326	+24	(1)	....
118	148173	CD−43°10810	21.1	−43 27	9.3	....	N	+ 5 *e*	.....	306	+ 2	....	....

TABLE I—*Continued*

	HD No.	Designation	1900 α	1900 δ	Magnitude Max.	Magnitude Min.	Type	Vel. Km/Sec. Abs.	Vel. Km/Sec. Em.	Galactic *l*	Galactic *b*	Notes	Period
													days
119	148182	V Oph	16h21m2	−12°12′	7.0	10.5	Nb	− 48 *d*	− 68	331°	+23°	....	301
120	....	SU Sco	34.2	−32 11	7.5	9.0	No	− 19 *c*	......	317	+ 8	....	....
121	156074	BD+42°2811	17 10.4	+42 15	7.7	....	RoR	− 11 *b*	......	37	+34	(1)(16)	....
122	....	CD−39°11452	20.7	−39 55	.....	....	(N3)	− 30 *e*	......	316	− 4	(2)	....
123	158377	TW Oph	23.8	−19 24	7.8	....	Nb	+ 14 *c*	......	334	+ 7	....	....
124	160205	TT Sco	33.5	−41 35	*9.0*	*11.2*	(N3)	+ 10 *e*	......	316	− 7	....	....
125	160591	CD−35°11829	35.7	−35 12	*10.7*	*11.6*	Nb	− 57 *e*	......	322	− 4	....	....
126	161208	SZ Sgr	39.1	−18 37	*8.5*	*9.8*	Nb	+ 17 *e*	......	336	+ 4	(20)	....
127	161511	SX Sco	40.8	−35 39	*9.6*	*11.1*	Nb	− 49 *e*	......	322	− 6	....	128?
128	....	T Dra	54.9	+58 14	7.5	14.0	Noe	− 12 *e*	− 38	53	+29	....	425
129	168227	BD−15°4923	18 13.6	−15 39	9.0	9.8	R5	− 19 *c*	......	344	− 2	(1)	....
130	170495	SS Sgr	24.6	−16 59	*11.0*	*12.0*	Nb	0 *c*	......	343	− 4	....	....
131	170831	TY Oph	26.4	+ 4 19	*9*	*10*	Nb	− 27 *e*	......	2	+ 5	....	....
132	....	T Lyr	28.9	+36 54	7.8	9.6	(N3)	− 21 *e*	......	33	+18	....	....
133	171804	RX Sct	31.7	− 7 41	*9.7*	*12.0*	Nb	− 2 *d*	......	352	− 2	....	....
134	173291	BD+36°3243	39.4	+36 51	8.1	....	Nb	− 6 *e*	......	33	+17	....	....
135	173409	CD−31°15954	40.0	−31 28	9.2	....	Ro	− 65 *e*	......	331	−14	(1)	....
136	174325	S Sct	44.9	− 8 1	6.4	7.3	NbN3	− 2 *b*	......	354	− 5	....	144
137	175377	T Sct	50.0	− 8 19	8.8	9.3	NbN3	+ 26 *c*	......	354	− 6	....	....
138	175893	CD−29°15574	52.4	−29 38	9.3	....	R1	+ 42 *c*	......	335	−16	(1)	....
139	176200	UV Aql	54.0	+14 14	*9.6*	*11.6*	NbN4	+ 21 *b*	......	14	+ 4	....	....
140	177336	V Aql	59.1	− 5 50	6.5	8.0	NpN6	+ 36 *c*	......	357	− 7	....	....
141	178316	BD−17°5492	19 3.0	−17 26	10.6	....	RoR4	− 45 *e*	......	347	−13	(1)	....
142	179153	....	6.3	− 1 33	*10.8*	*11.7*	Nb	+ 30 *e*	......	2	− 6	....	....
143	180953	....	13.4	−16 5	7.2	....	NaN2	− 46 *d*	......	349	−15	....	....
144	....	U Lyr	16.7	+37 37	8.3	12.0	(Noe)	− 2 *c*	− 36	37	+10	(2)	460
145	182040	BD−10°5057	17.7	−10 53	7.0	....	RoRo	− 49 *a*	......	354	−13	(1)	....

146	183556	UX Dra	19h 25m.1	+76°23′	6.1	7.1	NbNo	+ 7 d	......	75°	+24°	....	....
147	....	AW Cyg	25.8	+45 50	8.0	10.2	(N3)	− 12 c	......	46	+12	(2)	....
148	184283	AQ Sgr	28.6	−16 35	8.5	9.7	NbN3	+ 20 e	......	351	−18	(20)	....
149	186047	TT Cyg	37.1	+32 23	7.3	8.4	Nb	− 49 b	......	35	+ 4	....	120
150	186665	UW Sgr	40.6	−18 24	8.4	10.2	Na	+ 1 e	......	350	−22	....	....
151	188934	BD−0°3883	52.5	− 0 2	9.8	....	R3R8	+ 56 c	......	9	−16	(1)	....
152	189256	AX Cyg	54.0	+43 59	7.4	7.9	Nb	− 4 b	......	47	+ 7	....	....
153	189605	BD−7°5141	55.7	− 7 39	10.8	....	Nb	+ 41 e	......	2	−20	....	....
154	189711	BD+9°4369	56.3	+ 9 14	8.7	....	Nb	−164 e	......	17	−12	....	....
155	....	MSB 37	58.6	+30 23	.....	....	(N3)	+ 8 e	......	36	− 1	(2)	....
156	191738	SV Cyg	20 6.4	+47 33	8.1	9.4	NbN3	− 8 c	......	52	+ 8	....	....
157	192443	RS Cyg	9.8	+38 26	7.5	8.7	NapNope	− 46 e	− 55	43	+ 2	(20)	....
158	192737	RT Cap	11.3	−21 38	8.6	10.4	Nb	− 30 e	......	350	−29	....	....
159	193368	WX Cyg	14.8	+37 9	9.0	12.2	Nbe	+ 38 c	+ 2	43	0	....	410
160	193650	U Cyg	16.5	+47 35	6.1	11.8	R9Npe	+ 10	+ 3	52	+ 6	(9)(20)(22)	453
161	195435	BD−12°5755	26.2	−12 13	9.6	....	R5	− 52 c	......	1	−29	(1)	....
162	195665	AD Cyg	27.6	+32 14	8.5	9.5	S	− 1 e	......	41	− 5	(17)	73?
163	....	MSB 38	33.9	+59 44	.....	....	(N3)	− 43 e	......	63	+11	(2)	....
164	....	V Cyg	38.1	+47 48	6.8	13.8	Npe	+ 3 e	− 44	54	+ 3	(2)	416
165	....	BD+31°4201	39.4	+31 46	9.2	....	(N3)	− 24 e	......	42	− 7	(2)	....
166	197604	BD+34°4134	39.7	+34 43	9.8	....	R3	+ 21 c	......	44	− 7	(1)	....
167	198140	BD−19°5930	43.2	−19 24	10.3	....	Ro	+ 46 d	......	355	−36	(1)	....
168	....	BD+32°3954	45.2	+32 51	9.2	....	(N3)	− 11 e	......	44	− 7	(2)(18)	....
169	198681	....	46.9	+45 2	.....	....	Nb	− 7 e	......	53	0	....	....
170	202874	T Ind	21 13.6	−45 27	7.2	8.9	Na	+ 2	......	323	−46	(3)	....
171	205777	BD+60°2267	32.5	+60 28	10.3	....	(N3)	− 19 e	......	69	+ 6	....	....
172	206362	S Cep	36.4	+78 10	7.9	13.1	Nce	− 34 b	− 47	81	+19	....	482
173	206570	BD+34°4500	37.8	+35 3	6.4	....	NbN1	+ 6 b	......	53	−14	(20)	....
174	206750	RV Cyg	39.1	+37 34	7.1	9.3	NpN5	− 1 b	......	56	−11	....	....
175	208512	BD+49°3673	51.6	+50 2	9.8	....	Nc	− 12 d	......	64	− 4	....	....
176	208526	RX Peg	51.7	+22 24	7.7	8.6	NbN3	− 33 b	......	47	−25	....	175
177	209596	....	59.5	+45 5	.....	....	Na	− 22 e	......	63	− 8	(18)	....
178	209621	BD+20°5071	59.7	+20 34	8.8	....	R3R3	−383 b	......	47	−27	(1)(19)	....
179	209890	RZ Peg	22 1.5	+33 2	9.0	12.4	Ne	− 46 e	− 61	56	−18	....	440
180	215484	BD+60°2432	40.4	+61 12	9.0	....	Nb	− 37 e	......	76	+ 2	....	....

TABLE I—*Continued*

	HD No.	Designation	1900		Magnitude		Type	Vel. Km/Sec.		Galactic		Notes	Period
			α	δ	Max.	Min.		Abs.	Em.	*l*	*b*		
													days
181	216913	BD+53°3033	22h51m9	+53°41′	9.4	....	Nb	− 14 *e*	......	74°	− 5°	....	....
182	....	VY And	57.3	+45 21	9.5	11.0	Nb	− 12 *e*	......	72	−13	....	149
183	218851	BD−21°6376	23 6.3	−21 32	9.4	10.8	Ro	+ 32 *c*	......	11	−68	(1)	....
184	....	MSB 42	19.1	+55 26	.....	....	(N3)	− 34 *d*	......	79	− 4	(2)	....
185	220870	BD+48°4051	22.2	+48 58	9.7	....	Nb	− 10 *e*	......	77	−11	....	....
186	222241	ST And	33.8	+35 13	8.3	12.4	Nb	+ 32 *c*	+ 13	75	−25	....	338
187	223075	19 Psc	41.3	+ 2 56	5.3	....	NaNo	+ 7 *a*	......	63	−56	(10)(20)	....
188	223392	BD+5°5223	44.0	+ 5 50	8.8	....	R3	− 22 *e*	......	66	−53	(1)	....
189	224855	WZ Cas	56.2	+59 48	7.7	....	NaN1p	− 36 *b*	......	85	− 2	(20)280 Schj	....
190	224959	BD−3°5751	57.0	− 3 23	9.9	....	RoRo	−136 *e*	......	63	−64	(1)	....
191	225217	SU And	59.4	+43 0	7.9	8.5	Nb	− 6	......	82	−18	(24)	....

NOTES TO TABLE I

(1) Taken from *Mt. W. Contr.*, No. 276, Table I.

(2) See Merrill, Sanford, and Burwell, *Pub. A.S.P.*, **45**, 306, 1933. When no other designation exists for one of these stars the number is given from this publication.

(3) Moore's velocity, in *Lick Obs. Bull.*, **10**, 160, 1922, corrected by −7 km/sec.

(4) Called to my attention by S. B. Nicholson, who noted its extreme redness on photographs of comet Nagata (1931*b*). Discovered independently by Miss Burwell and Merrill.

(5) Velocities range from +26 to +50 km/sec.

(6) Velocity-curve by Sanford, *Mt. W. Contr.*, No. 372; *Ap. J.*, **68**, 408, 1928.

(7) Velocity-range from +7.1 to +18.4 km/sec. Coudé plates range from +10.0 to +18.4 km/sec.

(8) Velocity from absorption lines for only one plate. Velocity from emission lines is the mean of several plates.

(9) Velocity range for absorption lines, +4 to +37 km/sec. Range for emission lines, −13 to +23 km/sec.

(10) Velocity range for absorption lines, 0 to +15 km/sec.

(11) Class S with sometimes (?) class N added. Has 10^m A-type companion.

(12) One grating plate gives +23 km/sec.

(13) May be class S.
(14) Overlooked in solution.
(15) May be class K5R.
(16) Additional plate gives −12 km/sec.
(17) This is of spectral class S.
(18) This star has a fainter companion.
(19) Mean of two later plates, −383 km/sec.
(20) Very strong D lines.
(21) Seems to be variation in strength of the D lines.
(22) Velocity probably variable. Range −11 to +39 km/sec.
(23) D lines very weak.
(24) The good plates give +15, −17, and −15 km/sec. Velocity variable?
(25) Doubtful evidence of weak bright $H\alpha$ for this star.
(26) Velocity probably variable.
(27) Spectral classifications with numerical subscripts are those of Shane, *Lick Obs. Bull.*, **13**, 123, 1928, except those in parentheses, which are rough estimates by the writer based on Shane's system.
(28) General spectrum most nearly like that of 19 Piscium but much redder and D lines much more intense as, e.g., in R Leporis.
(29) Two better-exposed spectrograms give −167 and −167 km/sec. and seem also to have a pair of interstellar D lines with velocities of +1 and −5 km/sec.
(30) More recent data (Prager, "Katalog und Ephemeriden veränderlicher Sterne für 1935," *Kleinere Veröff. Universitätssternwarte Berlin-Babelsberg*, No. 14, 1934. Star 34 AV Aur $13^m.5$–15^mph; 39 SY Eri $8^m.0$–$9^m.6$; 42 S Aur $8^m.3$–12^m; 51 AZ Aur $10^m.5$–$15^m.5$ ph; 169 DS Cyg $12^m.9$–$15^m.1$ ph; 175 LW Cyg $10^m.5$–$11^m.5$ ph; 181 TV Lac $11^m.7$–$12^m.7$ ph.
(31) Obtained after solution was made.
(32) More recent velocity determinations for the following stars are:

No.	Vel.	No.	Vel.
8	−50 km/sec.	50	+20 km/sec.
21	−31	57	53
39	+ 4	73	48
40	+19	80	+10

(33) Velocity may be variable; range −35 to −55 km/sec.
(34) Velocity from D lines only.
(35) Composite spectrum; class A0 in the violet region. See Shane, *op. cit.*, p. 124.
(36) $H\alpha$ appears as an emission line on a spectrogram covering the region λλ 6500–7600, March 19, 1935, but with no certainty on any of the earlier spectrograms.

nitudes and periods was obtained from Prager's catalogue[9] and from the Mount Wilson discoveries previously alluded to. Galactic coordinates were taken from the Lund tables[10] for the nearest 4^m in α and 1° in δ. The magnitudes for some of the class-N stars in the *Henry Draper Catalogue* and most of those in the Mount Wilson list are not known. These latter were not in the *Henry Draper Catalogue* either because of extreme redness or extreme faintness or because the Harvard observations occurred at unfavorable phases in a great magnitude variation. Magnitudes in italics are photographic; the remainder are visual. Spectral classifications with numerical subscripts are from Shane's work,[11] rough estimates on his system for such stars as have not been otherwise classified being placed in parentheses. Under "Abs." are given the velocities from the absorption features, while "Em." denotes velocities from the emission lines of hydrogen, generally $H\alpha$ alone.

Velocities from the emission lines.—Two lists of stars of classes N and R with emission lines of hydrogen have been previously published,[12] and all these are again included in Table I. In these two lists the means of the difference in velocity between emission (generally $H\alpha$) and absorption lines are -27 and -25 km/sec., respectively. These, however, involve a few stars of spectral class R and all the absorption-line velocities for N-type stars on the old uncorrected system. In all, twenty stars of spectral class N with emission lines of hydrogen are entered in Table I. The mean difference between their velocities from emission and absorption is -21.6 km/sec., a numerical decrease from the two previously published values, attributable mainly to the application of the systematic correction to the absorption velocities and slightly to additional observations and to the limitation to only stars of class N.

The mean period for the seventeen of these twenty stars for which data are available is 407 days. The velocity difference here found

[9] "Katalog und Ephemeriden veränderlicher Sterne in 1934," *Kleinere Veröff. Universitätssternwarte Berlin-Babelsberg*, No. 13, 1933.

[10] John Ohlsson, *Ann. Obs. Lund*, No. 3, 1932.

[11] *Op. cit.*, **13**, 123, 1928.

[12] *Pub. A.S.P.*, **42**, 287, 1930; **45**, 44, 1933.

lies between those predicted by Merrill's[13] curves for stars of classes Me and Se. There is a slight correlation with period, smaller differences being associated with shorter periods, but this correlation is too poor to be stressed. With one exception these stars are variable, with a mean range of 4 mag. For some of them there are several spectrograms, representing all phases pretty well, which show that the hydrogen lines may vary from intense emission to practical extinction. Counting from maximum, the emission lines in R Leporis and U Cygni, for example, fade to extinction during the first quarter-period, remain suppressed for another quarter-period or until about light-minimum, then gradually increase, attaining maximum strength during the third quarter-period, which intensity continues until light maximum. The failure to find emission lines in the case of a star with large magnitude range might be attributed to the phase at which it was observed, the star being therefore no exception to the rule. In fact, I have found no certain evidence of bright hydrogen lines for four stars in whose spectra they were noted by Shane.[7] These are RV Cygni, $7^{m}.1$–$9^{m}.3$; Y Tauri, $6^{m}.9$–$8^{m}.9$, period 233 days; U Camelopardalis, $6^{m}.9$–$9^{m}.0$, period 418 days; and V Aquilae, $6^{m}.5$–$8^{m}.0$.

It would seem, therefore, that emission lines accompany a large magnitude range, that their failure to be observed in case the range is large is not necessarily evidence that they are not present at the appropriate phases, and that their appearance in a star of class N not known to vary should arouse a suspicion of variability. MSB 11 $\alpha = 4^{h}46^{m}.8$, $\delta = +49^{\circ}46'$ (1900), is an example of the last point.

Solar motion, galactic rotation, and absolute magnitude from the radial velocities of stars of spectral class N.—The recent success of Plaskett and Pearce[14] in finding evidence of galactic rotation, both from the radial velocities of the B-type stars and from their detached lines of calcium, and of A. H. Joy,[15] from the Cepheid variables, demands a similar treatment of whatever other data are available. Such an investigation evidently requires objects located at relatively large distances.

[13] *Mt. W. Contr.*, No. 264; *Ap. J.*, **58**, 251, Fig. 2, 1923.

[14] *Pub. Dom. Ap. Obs.*, **5**, 167–237, 1933.

[15] *Pub. A.S.P.*, **45**, 202, 1933.

Various investigators find values for the mean absolute magnitude of stars of spectral class N between the limits −1.3 and −2.5. Since their apparent magnitudes are in only a few cases brighter than 6 and in many cases fainter than 8, it is evident that N stars too are relatively distant objects and worthy of consideration in connection with the problem of galactic rotation. The 146 radial velocities of class-N stars in Table I are distributed among the different apparent visual magnitudes[16] roughly as follows:

Brighter than 6	11
6.0–6.9	27
7.0–7.9	32
8.0–8.9	28
9.0	48

The velocities show a very considerable spread which has been smoothed out for the purpose of solution by forming two groups for each band of 30° of galactic longitude, in one of which the galactic latitudes are positive and in the other negative. Since some bands are deficient in stars with negative values of the galactic latitude, twenty groups resulted. All velocities were given equal weight in forming a normal, as it seemed more important that each group depend upon all the stars included in it than largely upon the few better observed stars. No velocity, however large, was omitted.

Except for the effect of random motion, each of these twenty mean velocities (V) was assumed to be conditioned as follows:

$$V = K + X \cos b \cos l + Y \cos b \sin l + Z \sin b + du + ev \ .$$

l and b are the galactic longitude and latitude. The first member on the right is the well-known K-term; X, Y, and Z are the components of the solar motion referred to galactic co-ordinates. Further,

$$u = \bar{r}A \cos 2l_0 , \qquad d = \sin 2l \cos^2 b ,$$
$$v = \bar{r}A \sin 2l_0 , \qquad e = -\cos 2l \cos^2 b .$$

A is the galactic rotation effect for a distance of 1 kiloparsec and $\bar{r}$ is the mean distance in kiloparsecs; l_0 denotes the longitude of the galactic center.

[16] A variable star was assigned its magnitude at maximum; a photographic magnitude was reduced to a visual magnitude by the mean color index +2.6; and some of the Mount Wilson discoveries for which magnitudes are not available have been arbitrarily assigned to the ninth magnitude.

A least-squares solution of the twenty normal equations was then carried through, weights being assigned to each roughly proportional to the number of stars involved. The results are given in Table II.

TABLE II

$K = -0.9 \pm 1.7$ km/sec.	$Z = -12.4 \pm 5.8$ km/sec.
$X = -18.6 \pm 2.2$	$u = -0.15 \pm 2.3$
$Y = -6.5 \pm 2.8$	$v = -13.4 \pm 2.8$

The K-term is about one-half its probable error. The solar motion is 23.2 km/sec. toward the apex, whose right ascension is 17^h8^m and declination $+30°$, and thus agrees much better with that obtained from the naked-eye stars (20 km/sec. toward the apex with $\alpha = 18^h$ and $\delta = +30°$) than it does with Moore's[17] value (17.1 km/sec. toward the apex with $\alpha = 15^h$ and $\delta = +11°$) obtained from the radial velocities of only twenty-five bright class-N stars.

This solution gives the galactic rotation term ($\bar{r}A$) 13.4 km/sec. and the galactic center in the direction of $l_o = 315°$, for which Plaskett obtained 331° and Joy 324°. The latter's study of the Cepheid variables showed that galactic rotation increases by 18.5 km/sec. per kiloparsec from our stellar neighborhood, if absorption in space is allowed for. The mean distance in kiloparsecs may therefore be obtained, for the stars upon which it is based, by dividing the galactic rotation value ($\bar{r}A$) by 18.5. In this case the distance is 0.727 kiloparsecs, corresponding to an approximate mean parallax $\bar{\pi} = 0''.0014$. Although such a summary treatment of the data cannot give a rigorous value, it is of interest to note that the mean absolute magnitude from the foregoing value of $\bar{\pi}$ and the mean apparent magnitude, 7.9, is -1.4. Plaskett's value of A ($=15.5$) gives $M = -1.8$. Wilson[18] obtained the approximate value -1.4 for the mean absolute magnitude, using the proper motions of ninety-two class-N stars and assuming Moore's value of the velocity of the solar motion. With the solar motion here obtained, his absolute magnitude would become -2.1. Other absolute magnitudes from proper motions are:

No. of Stars		
?	-1.3	Luplau-Janssen and Haarh*
23	1.5	Moore†
120	-2.6	Kapteyn‡

* *A.N.*, **214**, 388, 1921. † *Lick Obs. Bull.*, **10**, 168, 1923. ‡ *Ap. J.*, **32**, 91, 1910.

[17] *Op. cit.*, p. 168.

[18] *A.J.*, **34**, 191, 1922.

Figure 1 shows how well the curve from this solution fits the twenty normal places reduced to $b = 0$. The ordinates are radial velocities and the abscissae, galactic longitudes. Barred circles represent the normal places from stars with negative galactic latitudes, and open circles those from stars with positive ones, accompanying numbers indicating how many stars are involved in each normal place.

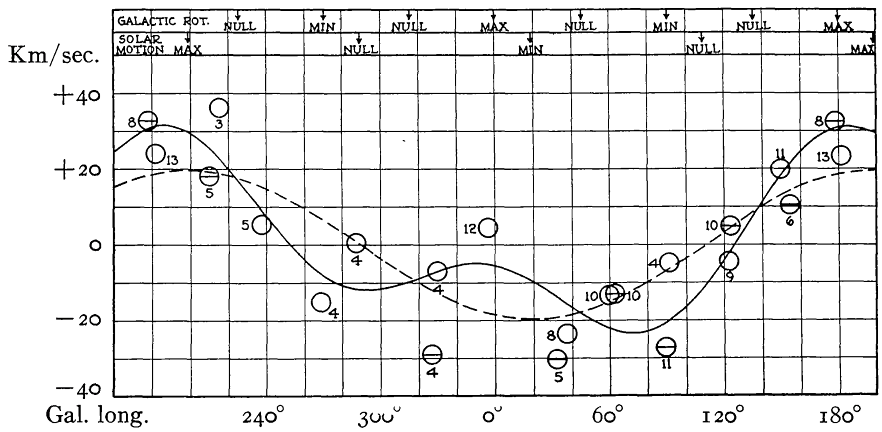

FIG. 1.—Solar motion and galactic rotation. Each circle represents a normal place, a bar indicating one derived from the velocities of stars in negative galactic latitudes. The number of velocities upon which a normal depends is given beside the circle. The full-line curve represents the combined solar motion and galactic rotation in the plane of the galaxy; the broken-line curve, the solar motion alone. Null, maximum, and minimum points for both galactic rotation and solar motion are given at the top of the figure.

It is frankly admitted that the scatter about the curve is considerable, which explains the large probable errors for the solution. It must be pointed out, however, that a representation of these normal places by solar motion alone would be quite unsatisfactory because the greater weight for the normals between galactic longitudes 70° and 180° would produce a sine-curve which would not at all represent the remaining galactic-longitude interval.

This solution is based upon class-N stars of all apparent magnitudes, but would be more convincing if the size of the galactic rotation term could be shown to depend upon mean apparent magnitude. To derive an approximate idea of this, the following procedure was adopted. It was first assumed that these stars give the ordinary solar apex with the solar motion velocity (23 km/sec.) here obtained, and their individual velocities were corrected accordingly. Only stars with galactic latitudes between $+40^\circ$ and -40° were used, and one velocity exceeding -100 km/sec., which may in reality belong to spectral class R, was excluded. These were next divided into three groups according to apparent magnitude: the first, the stars brighter than 7.2; the second, those between this limit and 8.9; and a third group, the remainder, 9.0 or fainter. Finally, a least-squares solution was carried through for the stars in each group in which the residual velocity is represented by the conditional equation

$$\rho = \bar{r}A \sin 2(l - 315^\circ) \cos^2 b \, .$$

TABLE III

No.	$\bar{r}A$ Km/Sec.	$\bar{r}$ Kiloparsecs		Mean Magnitude			$\bar{\rho}$ Km/Sec.
		$A=18.5$	$A=15.5$	App.	Abs. $A=18.5$	Abs. $A=15.5$	
41	7.2	0.390	0.465	6.5	−1.4	−1.8	17.3
48	16.3	0.879	1.050	8.2	1.5	1.9	21.6
44	22.4	1.211	1.445	9.3	−1.1	−1.5	22.1

Column 2, Table III,[19] gives the results of these solutions. The other columns contain, respectively: (1) the number of stars; (3) and (4) the mean distances obtained when Joy's A and Plaskett's A are assumed; (5) the mean apparent magnitudes; (6) and (7) the mean absolute magnitudes on the basis of the two values of A; and (8) the mean velocities freed from solar motion, sign being disregarded.

$\bar{r}A$ increases steadily with mean apparent magnitude; hence the reality of the rotation term from the general solution is greatly strengthened by the foregoing treatment. The spread in the derived absolute magnitudes is no more than might be expected from the probable errors, the uncertainties of the individual mean magnitudes

[19] The data in this table are to be preferred to those already given in *Pub. A.S.P.*, **46**, 228, 1934. The changes arise mainly from the use of the velocity from the solution for solar motion based on the N stars themselves; whereas the velocity derived from the naked-eye stars was used for the earlier results.

for the fainter stars, and the effect of space absorption. Moreover, any spread in the individual absolute magnitudes could result in a fainter mean absolute magnitude for the group of apparently faintest stars, since more of the absolutely fainter stars would conceivably enter such a group.

Although the absolute magnitudes of column 7 (using Plaskett's *A*) agree better with Wilson's mean absolute magnitude as revised, −2.1, the absolute magnitudes of column 6 are tentatively adopted; for Joy's *A* upon which they depend is based upon not only the radial velocities of, but also the space absorption for, the Cepheid variables, the range of whose distances considerably exceeds those for the stars of class B. The weighted mean *M* from column 6 is −1.34, in good agreement with the value −1.4 given earlier from all class-N stars.

The weighted mean of the peculiar motions without regard to sign ($\bar{\rho}$) is 20.4 km/sec., thus exceeding by 3.9 km/sec. the mean peculiar motion of class-M stars found by Campbell. Larger values, however, have been obtained by Merrill[20] for some subdivisions of spectral classes Me and Se.

Double stars.—The following class-N stars have companions:

		1900 α	1900 δ						
HD 32218	TU Tauri.......	$5^h39^m.1$	+24°23′	$8^m.7$–$9^m.5$ Composite N2+A0					
	MSB 31........	7 45.0	− 0 38						
βGC 10554	BD+32°3954...	20 45.2	+32 51	9.2	*AB* pa	243°	dist. 10″.6	$9^m.1$–$10^m.0$
					AC pa	140	18.3	10.7
	HD 209596.....	21 59.5	+45 5					

The components of the last three stars are widely separated, with the secondaries considerably fainter than the primaries. The first and third entries furnish some data about the absolute magnitudes of the class-N primaries. In the case of TU Tauri the secondary is estimated by Shane[21] to be a class-A0 star of apparent magnitude 11. The absolute visual magnitude of TU Tauri comes out −1.8 at maximum, if the most frequent absolute magnitude (+0.5) for type A0, as given by Strömberg,[22] is assumed. A spectrogram of com-

[20] *Mt. W. Contr.*, No. 264; *Ap. J.*, **58**, 166, 1923.

[21] *Op. cit.*, **13**, 124, 1928.

[22] *Mt. W. Contr.*, No. 442; *Ap. J.*, **75**, 341, 1931.

ponent B of the third entry shows a class-G6 spectrum from which the absolute magnitude was estimated to be +0.1. On the assumption of physical connection, the derived absolute magnitude of A is −0.8. Its radial velocity is −11 km/sec. (low weight) and that of B, +8 km/sec. (depending on a single plate). Neither the magnitudes of the components nor the spectra of the secondaries are known in the other two cases. Such evidence as the first and third pairs furnish is in as good agreement with the results for absolute magnitude from the rotation effect as could be expected.

In conclusion, it seems appropriate to admit candidly the limitations in the accuracy of the velocities in Table I, which depend in a considerable degree upon few observations and often upon spectrograms of low dispersion. The velocities from spectrograms of low dispersion when compared with velocities obtained with higher dispersion have revealed no anomalies. Sufficient stars have been repeatedly observed to establish the fact that only a very few have velocity ranges which much exceed the accidental error to be expected. Hence it seemed best to concentrate upon securing approximate velocities for the greatest possible number of stars of class N rather than struggle for greater accuracy for a few stars. This assumes that the mean of a large number of approximate velocities better typifies the mean motion of a group of stars than does the mean of a few accurate velocities, some of which might represent abnormally large peculiar motions. Indeed, the final results would have differed very little from those actually obtained if the velocities from the first spectrogram of each star had been made the basis of the solutions.

Carnegie Institution of Washington
Mount Wilson Observatory
April 1935