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A SURVEY OF THE SPECTRA AND RADIAL VELOCITIES OF THE LESS REGULAR M-TYPE VARIABLE STARS*

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ABSTRACT

The spectra of 118 variable M-type stars characterized by small and irregular light-changes and by the absence or weakness of emission lines were examined with respect to their spectral classification, spectroscopic absolute magnitude, and radial velocity. Of these stars, 105 were previously unobserved spectroscopically.

Distribution.—The supergiants have a mean galactic latitude of 11°, but the normal giants, like the Me variables, show little galactic concentration.

Spectroscopic absolute magnitude.—The 1935 Mount Wilson curves were used. For the supergiants the absolute magnitudes are scattered from −2.0 to −4.5; for the normal giants the mean is −0.9, which corresponds closely with that of the Me variables.

Spectral type.—The stars are largely concentrated in classes M5 and M6. The supergiants are found in the earlier types from M0 to M5. For a given type the periods are much shorter than in the Me variables.

Radial velocities.—The mean residual velocity of the supergiants is 18.2 km/sec; of the giants, 26.1 km/sec. The stars with shorter period show a larger mean velocity and greater scatter.

Displacements of emission lines.—Emission at certain phases is shown by 19 stars. The mean violet displacement of the bright lines is 8.9 km/sec with respect to the absorption lines. The relationship between shift and spectral type corresponds closely with that of the Me variables.

Giant M-type stars are particularly subject to fluctuations in light. It has been suspected that practically all red stars vary more or less in total luminosity.[1] About two-thirds of all known intrinsic variable stars have titanium oxide bands in their spectra and show strong hydrogen emission except at minimum light. In their light-changes and general behavior these emission stars resemble Mira and are known as long-period, or Me, variables. Although considerable irregularity is often present in their light-curves, the period is fairly definite. The variation in visual light is several magnitudes, but the velocity-changes are small and have been detected in few stars. The motions and spectroscopic characteristics of the Me variables are well known, largely through the studies of P. W. Merrill.

The remaining variables with M-type spectra showing little or no emission may not form a homogeneous group, but they can be readily separated from the Mira stars, because of their irregular light-curves, smaller magnitude ranges, and the absence of strong emission lines in their spectra. Their periods, in general, are poorly defined, and often no certain regularities in their light-changes can be found. Usually the periods which have been deduced are between 50 and 150 days and in the mean are markedly shorter than those of the Mira stars. For this reason it might be expected that the physical properties of this group would be intermediate between the long-period and the Cepheid classes. The results of this investigation, however, indicate that these less regular stars are closely related to long-period variables in most of their characteristics.

In the region of the sky suitable for observation at Mount Wilson, Schneller's *Catalogue and Ephemeris of Variable Stars* for 1939[2] lists 202 semiregular and irregular M-type variables without bright lines and, in addition, 67 stars, which, on account of small magnitude range or intermediate period (50–150 days), might be expected to fall outside the Mira class, even though no spectral classification was available.

* *Contributions from the Mount Wilson Observatory, Carnegie Institution of Washington*, No. 668.

[1] Joel Stebbins, *Pub. A.A.S.*, **6**, 244, 1928.

[2] *Kleinere Veröff. Sternwarte Berlin-Babelsberg*, No. 20, 1938.

The spectral types and mean radial velocities for 13 of the brightest of these variables have been previously published[3] and are given in Table 1. In the column headed V' is given the radial velocity corrected for a solar motion of 20 km/sec. No certain changes in spectra during the cycle of light-variation were recorded, and velocity-changes, except for V UMi, are not much greater than the errors of measurement. Several of the stars will be recognized as supergiants of a much higher order of luminosity than the ordinary giant M or Me stars.

Selection of stars.—This study was begun some ten years ago for the purpose of determining the motions and spectral features of those M-type variables which had not been included in the lists of other observers. The program was limited for the most part

TABLE 1

PUBLISHED DATA FOR IRREGULAR M-TYPE VARIABLES

Star	m_v	Sp.	Meas. V	V'	Vel. Range	Observer
			km/sec	km/sec	km/sec	
RS Cnc	5.3–6.8	M6	+ 12.8	+ 6.8	6	McLaughlin*
μ Cep	4.0–4.8	M2	+ 20.5	+ 34.2	14	Campbell†
η Gem	3.2–4.2	M3	+ 19.4	+ 6.9	10	Reese‡
α Her	3.1–3.9	M5	− 32.6	− 13.6	6	Lick§
g Her	4.4–5.6	M6	+ 3.3	+ 21.6	5	Lick,§ Mt. Wilson‖
R Lyr	4.0–4.5	M5	− 28.3	− 9.3	6	Lick,§ Sanford¶
α Ori	0.1–1.2	M2	+ 21.0	+ 5.0	4	Lick,§ Cape,** Sanford††
CI Ori	4.5–5.5	M0	+ 7.5	− 10.0	10	Lick,§ Mt. Wilson‖
SX Pav	5.3–6.3	M6	+ 42.9	+ 37.4	8	Lick§
ρ Per	3.2–4.1	M4	+ 28.2	+ 24.6	1	Lick§
TV Psc	5.1–5.5	M3	+ 5.2	+ 6.6	10	Lick,§ Mt. Wilson‡‡
α Sco	0.9–1.8	M1	− 3.0	+ 6.8	4	Lick,§ Cape**
V UMi	7.1–8.9	M4	−165	−154	27	Redman,§§ Sanford‖‖

* *Pub. Univ. of Michigan*, **8**, 118, 1941.
† *Lick Obs. Bull.*, **7**, 102, 1912.
‡ *Lick Obs. Bull.*, **1**, 158, 1902.
§ *Lic Obs. Pub.*, **16**, 1928.
‖ *Mt. W. Contr.*, No. 387; *Ap. J.*, **70**, 207 1929.
¶ *Mt. W. Contr.*, No. 394; *Ap. J.*, **71**, 209, 1930.
** *M.N.*, **88**, 660, 1928.
†† *Mt. W. Contr.*, No. 464; *Ap. J.*, **77**, 110, 1933.
‡‡ *Mt. W. Contr.*, No. 105; *Ap. J.*, **42**, 175, 1915.
§§ *M.N.*, **92**, 118, 1931.
‖‖ *Mt. W. Contr.*, No. 481; *Ap. J.*, **79**, 77, 1934.

to stars north of declination −26° and brighter than twelfth magnitude which could be observed with the one-prism spectrograph of the 60-inch reflector and was intended to include a variety of nonemission variable stars with intermediate periods or with small light-ranges. Some preference was, perhaps, given to stars with assigned periods and recent discoveries may be somewhat neglected. As far as our present knowledge goes, the list is fairly representative of this class of stars. It contains about half of the known variables of this kind having assigned periods, together with a moderate sampling of the more irregular stars. While the program is in no sense complete, it serves as a preliminary basis for the study of a group of stars about which little precise information has heretofore been available.

Although one of the criteria of selection was the absence of bright lines, no stars being retained which showed emission on all plates, nevertheless, weak or moderately strong

[3] Since this paper was written, P. C. Keenan has published (*Ap. J.*, **95**, 461, 1942) the spectral types and luminosity classes of 67 semiregular or irregular variables of types K and M observed in November and December, 1941, with the McDonald reflector. Thirty-seven of his stars are common to this Mount Wilson list. His spectral types are about 0.4 of a subdivision earlier than those given here, and his absolute magnitudes of supergiants, based largely on standards taken from the Perseus double cluster, are more than a magnitude brighter than those determined from the Mount Wilson curves. In general, the results of the two papers are in satisfactory agreement.

hydrogen emission lines were found on one or more spectrograms of 19 stars of the list, and emission lines of neutral silicon also appear on a few. In addition, emission was previously detected in 3 of the stars (RS Cnc, AF Cyg, X Her) by D. B. McLaughlin at the University of Michigan and in 11 stars (RV And, RU Aqr, S Crt, AB Cyg, UW Her, ST Peg, RW Psc, Y Ser, V UMa, RY UMa, W Vul) by observers at the Harvard College Observatory. At one time or another, then, 33 of the 118 stars observed have shown bright lines. The presence of emission does not seem to be correlated with other physical characteristics, but it usually occurs near maximum or during increasing light.

I am indebted to my colleagues, Mr. P. W. Merrill, who was kind enough to turn over to me 24 plates of 17 stars which he found to lack the emission characteristics of the Me variables, and Messrs. W. S. Adams, R. F. Sanford, and G. Strömberg, who obtained a number of the plates used in this study.

The observations.—Two or more spectrograms of each star on the program were obtained as opportunity permitted, without much consideration of phase. The dispersion depended on the brightness of the star and the observing conditions at the time. Many lines or blends were identified even with low dispersion, and 15 or 20 were measured on each good plate. Radial velocities were determined with the aid of Merrill's wave lengths.[4] The results for 105 stars previously unobserved are listed in Table 2. The first column gives the name of the star and its period (in parenthesis), its positional designation according to the Harvard system, and the visual magnitude at maximum and minimum from Harvard publications or from Schneller's *Catalogue*. The spectral types (fifth column) are based on the strength of the titanium oxide bands. The velocities (sixth column) are determined by measurement of the absorption lines. The dispersions given in the eighth column are approximately: $a=36$, $b=70$, and $c=120$ A/mm at $H\gamma$. The weights in the last column are arbitrarily assigned with reference to the dispersion, the number of lines measured, and the quality of the plate.

The elements from which the phases (fourth column) are computed may be found in the notes to the table. Periods have been assigned for 89 stars, and phases are computed for 46, but for most of them the irregularities of the light-changes make the elements quite unreliable. The phases should be used with caution. They are entered in the table to show the distribution of the observations over the cycle of the light-variation. In very few of the stars is it possible to detect any correlation between light- and velocity-variations; but for a proper study of such relationships it is imperative that simultaneous observations of light- and velocity-changes should be carried out. The velocity-range is small; hence it is difficult to separate any variation of velocity during the cycle from errors of observation. Additional evidence of variation can be obtained only at the expense of a many fold increase in the number of observations of each star.

Collected data for the irregular M-type variables.—A summary of the astrophysical data now available for 118 irregular M-type variables is in Table 3. This table includes the galactic co-ordinates, the apparent visual magnitude at maximum light, the spectroscopic absolute magnitude, the corresponding photometric parallax, the spectral type, the mean measured and residual radial velocity (corrected for a solar motion of 20 km/sec toward the usual apex), and the period of light-variation.

Distribution of stars.—The lack of observations of stars in the southern skies results in an unbalanced distribution, which makes the material unsuitable for many statistical investigations. There is little galactic concentration for the stars observed. The average latitude is 29° for the giants, which is closely the same as that of the Me stars[5] but widely different from that of the δ Cepheids,[6] for which the value is 5°. The average latitude of the 13 supergiants, however, is only 11°.

[4] *Mt. W. Contr.*, Nos. 265 and 644; *Ap. J.*, **58**, 195, 1923; **93**, 381, 1941.

[5] P. W. Merrill, *Mt. W. Contr.*, No. 649; *Ap. J.*, **94**, 208, 1941.

[6] A. H. Joy, *Mt. W. Contr.*, No. 607; *Ap. J.*, **89**, 361, 1939.

TABLE 2

OBSERVATIONS OF IRREGULAR M-TYPE VARIABLES

Star, Period, Designation, Magnitude	Plate	JD 242	Phase	Spectrum	Vel.	Disp.	Wt.
			days		km/sec		
RU And (231[d])							
013238	C 7216	9183	38	M6	....	b	0.0
10.0–13.7	E 61	9913	75	6e	− 43	c	0.6
	C 7658	0029*	190	6	....	c	0.0
	E 250	0248*	178	6e	− 39	c	0.6
	318	0298*	228	5e	− 45	c	0.6
					− 42		
RV And (229)							
020448	γ17729	6222	....	M5	− 14	b	1.0
8.7–11.4	C 6588	7763	....	5	− 14	b	1.0
	γ20874	8117	....	5	− 6	b	1.0
	C 7155	8936	....	5	− 4	c	0.4
					− 10		
SS And (160)							
230752	γ21248	8852	....	M6	− 23	c	0.6
8.9–9.9	22204	9562	....	6	− 32	c	0.4
	C 7541	9854	....	6	− 15	c	0.6
	γ22999	9894	....	5	− 22	b	1.0
					− 22		
TV And (114)							
225342	C 2387	3652	....	M5	....	b	0.0
8.8–11.1	7517	9826	....	5e	− 47	c	0.6
	γ22857	9858	....	4e	− 51	b	1.0
					− 50		
TY And (150)							
231040	γ20791	7971	....	M6	....	b	0.0
8.2–10.0	22994	9893	....	6e	− 8	b	1.0
	23134	9927	....	5e	− 3	b	1.0
	23839	0301*	....	6	− 9	c	0.4
					− 6		
TZ And (280)							
234546	γ12878	4014	....	M6	....	b	0.0
8.5–9.5	22205	9562	....	5	− 28	c	0.6
	C 7552	9856	....	6	− 33	b	1.0
					− 31		
RU Aqr (69)							
231917	C 2938	4013	31	M6	+ 22	b	1.0
9.0–10.3	5808	6557	33	5	+ 32	b	1.0
	γ23154	9943	53	6	+ 22	c	0.6
					+ 26		
TW Aqr (79)							
205802	γ22776	9827	63	M5	− 41	c	0.6
9.3–10.3	C 7544	9854	11	6	− 34	c	0.6
					− 38		

* The first three figures of the JD number are 243.

TABLE 2—*Continued*

Star, Period, Designation, Magnitude	Plate	JD 242	Phase	Spectrum	Vel.	Disp.	Wt.
			days		km/sec		
BM Aqr (—)							
2201*16*	C 6953	8409	....	M4	−18	c	0.4
9.0–10.2	γ22777	9827	....	5	−33	c	0.6
	22851	9856	....	5	−11	c	0.6
					−21		
TZ Aql (90)							
2025*05*	C 4467	5165	....	M6	+52	b	1.0
8.5–9.5	γ21867	9414	....	6	+48	c	0.6
	E 51	9912	....	6	+50	b	1.0
					+50		
WX Aql (105)							
194303	C 7506	9806	86	M6	−21	c	0.6
8.8–9.9	7548	9855	30	6	−29	c	0.6
	γ22996	9894	69	6	−33	c	0.6
					−28		
KN Aql (139)							
202501	C 7516	9825	58	M5	−140	b	1.0
7.7–9.2	γ22997	9894	127	5e	−148	b	1.0
	E 312	0297*	113	5	−128	c	0.6
					−140		
LU Aql (50)							
193415	C 7091	8733	....	M4	−1	b	0.7
9.2–10.3	γ21866	9414	....	4	+3	c	0.2
	C 7505	9806	....	4	+6	c	0.6
					+2		
NO Aql (66)							
194004	γ23143	9932	62	M3	−96	c	0.6
9.9–11.2	23155	9944	7	4	−91	c	0.6
	23205	9970	33	4e	−105	c	0.4
	E 477	0515*	50	3	−108	c	0.6
					−99		
PX Aql (—)							
1952*09*	C 6273	7267	....	M5	−34	c	0.6
9.2–10.7	γ22736	9803	....	5	−36	c	0.6
					−35		
TU Aur (75)							
062845	γ21674	9293	....	M5	+12	b	1.0
7.7–9.1	22418	9647	....	5	+5	b	1.0
					+8		
UX Aur (90)							
050849	C 4439	5159	....	M5	+34	b	1.0
8.0–8.8	γ21275	8910	....	5	+33	b	1.0
					+34		
UZ Aur (66)							
050840	E 56	9912	....	M4	+15	c	0.6
7.7–9.3	C 7650	0002*	....	4	+24	b	1.0
					+21		

TABLE 2—*Continued*

Star, Period, Designation, Magnitude	Plate	JD 242	Phase	Spectrum	Vel.	Disp.	Wt.
			days		km/sec		
RV Boo (138)							
143532	C 5139	5671	....	M6	− 7	b	1.0
7.6–8.6	γ17376	6076	....	6e	− 9	b	1.0
	17424	6104	....	6e	+ 1	b	1.0
	17473	6130	....	6	+ 3	b	1.0
	17541	6154	....	5	− 5	b	1.0
	17571	6168	....	6e	− 5	b	1.0
	17634	6198	....	6	− 1	b	1.0
					− 3		
RW Boo (373)							
143632	γ22589	9764	....	M5	− 9	b	1.0
7.3–7.7	22739	9804	....	5	− 13	b	1.0
					− 11		
RX Boo (78)							
141926	γ21688	9322	....	M7	− 15	b	1.0
7.0–9.2	21722	9351	....	8e	− 8	a	1.5
	C 7277	9379	....	8.	− 8	b	1.0
					− 10		
RR Cam (123)							
052372	γ19190	6992	....	M6	− 61	b	1.0
9.2–10.6	21285	8935	....	6	− 60	c	0.4
					− 61		
RS Cam (89)							
083679	γ12291	3746	....	M6	− 30	b	0.3
8.1–9.5	17137	5960	....	6	− 35	b	0.3
	17375	6076	....	5	− 38	b	0.7
	17478	6131	....	6	− 37	c	0.2
	18029	6343	....	6	....	b	0.0
	18143	6427	....	5	− 42	b	0.7
	18752	6784	....	5	− 47	b	1.0
					− 41		
RV Cam (103)							
042257	γ22209	9563	....	M6	− 16	b	1.0
7.9–9.0	C 7649	0002*	....	5	− 26	b	1.0
					− 21		
RY Cam (135)							
042164	γ13247	4186	....	M3	− 14	b	0.3
8.0–9.2	14545	4781	....	4	− 18	b	0.3
	22208	9562	....	4	− 27	b	1.0
	22421	9648	....	3	− 23	b	1.0
	22478	9679	....	4	− 22	b	1.0
					− 23		
Z Cnc (80)							
081615	C 2582	3772	....	M7	+ 8	b	1.0
8.5–9.8	5133	5669	....	7	+ 5	b	1.0
	5159	5722	....	6	+ 7	b	1.0
	5368	5959	....	6	0	b	1.0
	5399	6019	....	6	− 4	b	1.0
	γ17944	6316	....	6	+ 14	b	1.0
	C 5653	6338	....	7	+ 1	b	1.0
					+ 4		

TABLE 2—*Continued*

Star, Period, Designation, Magnitude	Plate	JD 242	Phase	Spectrum	Vel.	Disp.	Wt.
			days		km/sec		
RS Cnc (239)							
090431	γ19524	7137	113	M6	+ 13	a	1.5
5.3–6.8	21858	9413	0	6	+ 15	a	1.5
	C 7326	9440	26	5	+ 2	b	1.0
	γ22419	9647	233	6	+ 12	a	1.5
					+ 11		
RT Cnc							
085211	C 7293	9393	89	M5	+ 13	b	1.0
7.3–8.6	γ21863	9414	15	5	+ 38	b	1.0
	C 7662	0029*	64	6	+ 27	b	1.0
	E 86	0090*	31	6	+ 43	b	1.0
	104	0119*	60	6	+ 44	b	1.0
	147	0148*	89	5	+ 51	b	1.0
					+ 36		
RV CMa (—)							
065614	γ19456	7105	....	M6	+ 29	c	0.4
8.9–9.7	C 7666	0030*	....	6	+ 26	c	0.6
					+ 27		
VY CMa (—)							
071825	C 7450	9670	....	M4	....	b	0.0
7.8–9.8	7667	0030*	....	4e	+ 45	b	0.7
	γ23338	0070*	....	3e	+ 42	c	0.6
	E 419	0443*	....	4e	+ 67	c	0.4
					+ 49		
UX CMi (151)							
074005	γ22555	9736	138	M5	+ 25	c	0.6
8.5–9.5	23313	0034*	134	5	+ 25	c	0.6
					+ 25		
UY Cas (102)							
225757	γ19261	7021	6	M4	− 10	b	0.7
9.6–11.5	22106	9505	30	3e	− 1	b	1.0
	E 347	0326*	31	4e	− 1	c	0.6
					− 4		
VY Cas (100)							
004562	γ21249	8852	....	M6	− 92	c	0.6
9.0–10.2	23001	9894	....	6	− 92	b	1.0
					− 92		
SS Cep (98)							
033380	γ17937	6314	48	M6	− 36	b	1.0
6.7–7.8	22416	9647	66	6	− 46	b	1.0
					− 41		
T Cet (160)							
001620	γ12874	4012	....	M5	+ 29	a	0.5
5.2–6.0	12924	4037	....	5e	+ 28	a	1.0
	13017	4073	....	5e	+ 17	a	1.5
	13500	4333	....	5	+ 37	a	0.5
	13594	4365	....	5	+ 26	a	0.5
	13680	4393	....	5	+ 26	a	1.5
	13727	4404	....	5	+ 28	a	1.5

TABLE 2—*Continued*

Star, Period, Designation, Magnitude	Plate	JD 242	Phase	Spectrum	Vel.	Disp.	Wt.
			days		km/sec		
T Cet (160) *Cont.*	13827	4432	....	M5	+ 35	a	1.5
	13848	4450	....	5	+ 40	a	1.0
					+ 29		
Y CrB (300) 154338 9.8–10.8	γ22481	9679	....	M8	− 19	c	0.6
	22560	9737	....	8	− 22	c	0.6
					− 20		
RR CrB (57) 153738 7.2–8.4	C 5978	6783	11	M5	− 54	b	1.0
	5992	6811	39	5	− 38	b	1.0
	6256	7226	56	5	− 57	b	1.0
					− 50		
RU CrB (436) 153126 8.8–11.4	C 6048	6880	....	M5	− 15	c	0.2
	γ21856	9412	....	5	− 27	c	0.6
	21988	9469	....	5	− 31	c	0.6
					− 27		
X Crv (127) 124318 7.8–8.8	γ22425	9649	....	M6	+ 6	b	0.7
	C 7452	9670	....	6	− 5	b	1.0
	γ23336	0070*	....	6	+ 7	c	0.4
					+ 1		
S Crt (152) 114707 8.4–9.5	C 5137	5670	....	M6	....	b	0.0
	7663	0029*	....	6	+ 35	c	0.6
	γ23329	0069*	....	6	+ 27	c	0.4
					+ 32		
RZ Cyg (546) 204846 9.6–13.6	C 7372	9508	538	M7	....	b	0.0
	γ23156	9944	428	7	− 51	c	0.6
	E 94	0091*	30	7	− 42	c	0.6
	316	0298*	236	7	....	c	0.0
					− 47		
AB Cyg (482) 213231 7.7–8.9	γ17778	6233	405	M4	− 17	b	1.0
	C 5748	6494	184	5	− 8	b	1.0
	5804	6555	245	4	0	b	1.0
	6532	7680	451	4	− 4	b	0.7
					− 7		
AF Cyg (94) 192745 6.4–8.4	γ12819	3987	43	M6	− 20	a	1.5
	12877	4014	70	6	− 7	b	0.3
	13458	4313	69	6	− 9	b	1.0
	C 3889	4719	69	6	− 12	a	1.5
	γ17482	6131	15	6	− 19	b	1.0
	17530	6140	24	6	− 12	b	1.0
	17772	6232	22	6	− 24	b	0.7
	17789	6255	55	6	− 2	b	0.3
					− 15		

TABLE 2—*Continued*

Star, Period, Designation, Magnitude	Plate	JD 242	Phase	Spectrum	Vel.	Disp.	Wt.
			days		km/sec		
AI Cyg (140)							
202732	C 7296	9393	74	M6	− 50	c	0.6
8.4–9.7	7519	9826	86	6	− 64	b	1.0
	E 58	9913	34	6	− 56	c	0.6
					− 58		
BC Cyg (—)							
201737	C 7550	9855	....	M4	− 6	b	0.7
9.8–10.8	γ22993	9893	....	3	+ 1	c	0.6
					− 3		
CH Cyg (101)							
192150	γ12914	4036	39	M7	− 53	a	1.5
6.4–7.4	13578	4362	64	6	− 51	a	1.5
	C 3480	4393	95	6	− 52	a	1.5
	γ17477	6130	21	6	− 59	b	1.0
	17726	6222	12	6	− 51	b	1.0
					− 53		
U Del (—)							
204017	γ22757	9824	....	M5	− 19	a	1.5
5.6–7.5	23142	9932	....	5	− 23	b	1.0
					− 21		
S Dra (—)							
164055	C 7457	9703	....	M6	+ 10	b	1.0
7.5–9.3	γ22557	9736	....	6	− 2	c	0.6
					+ 6		
SS Dra (48)							
122169	γ22424	9648	....	M5	+ 28	b	1.0
8.6–10.0	22480	9679	....	5	+ 38	b	1.0
					+ 33		
SZ Dra (120)							
190965	γ22559	9736	....	M5	− 41	b	1.0
8.0–8.6	22590	9764	....	5	− 42	b	1.0
					− 42		
TT Dra (107)							
171157	C 4255	5011	71	M6	− 38	b	0.7
8.5–9.3	5456	6111	97	6	− 26	b	0.3
	γ17572	6168	47	6	− 9	b	0.7
	C 5716	6459	16	6	− 24	b	0.3
	6054	6881	88	6	− 16	b	0.7
					− 23		
TX Dra (134)							
163360	γ12815	3986	59	M5	....	b	0.0
6.8–8.1	13457	4313	118	4	+ 58	b	1.0
	13483	4331	2	4	+ 42	a	1.0
	13583	4364	35	5	+ 51	a	0.5
	C 3717	4574	111	5	+ 58	b	1.0
	3769	4631	34	4	+ 40	a	1.0
	γ14208	4658	61	5	+ 60	a	0.5
	C 3842	4689	92	5	+ 54	a	1.0
	3878	4714	117	5	+ 54	a	1.0

TABLE 2—*Continued*

Star, Period, Designation, Magnitude	Plate	JD 242	Phase	Spectrum	Vel.	Disp.	Wt.
			days		km/sec		
TX Dra (134) *Cont.*	3896	4720	123	M4	+ 51	a	1.5
	γ15002	5023	24	4e	+ 52	a	1.5
					+ 52		
UU Dra (234)							
202574	γ22585	9763	81	M8	− 17	b	0.3
8.7–10.3	22743	9804	122	8	− 45	b	1.0
	22754	9823	141	8	− 34	b	1.0
					− 37		
UV Dra (77)							
144156	C 1600	3124	4	M5	− 46	b	0.3
8.8–9.4	3855	4692	24	6	− 34	b	1.0
	4766	5362	75	5	− 23	b	0.7
	γ16575	5750	76	5	− 21	b	0.3
	C 5394	6019	35	5	− 46	b	0.7
	5455	6111	50	5	− 21	b	1.0
	γ17484	6132	71	5	− 33	b	0.7
	C 5692	6427	57	5	− 37	b	1.0
	5720	6461	13	5	− 36	b	1.0
	5752	6515	67	5	− 47	b	0.3
	6011	6840	5	5	− 41	b	1.0
	γ18913	6882	47	5	− 37	b	1.0
					− 35		
Z Eri (—)							
024312	γ17632	6197	....	M5	+ 3	b	1.0
6.4–7.7	22477	9679	....	5	− 22	b	1.0
	E 289	0269*	....	5	− 24	c	0.6
					− 14		
RW Eri (91)							
041705	C 5386	6017	6	M6	+118	b	0.3
8.6–9.6	5631	6312	27	6	+106	b	1.0
	γ23820	0280*	64	6	+108	b	0.7
	23903	0327*	20	6	+101	c	0.6
					+107		
Y Gem (—)							
073520	C 5380	5961	....	M6	+ 18	a	1.0
8.5–10.0	7456	9703	....	6e	+ 18	b	1.0
					+ 18		
TV Gem							
060521	E 409	0416*	....	M2	+ 16	b	1.0
7.0–7.8	γ24052	0423*	....	2	+ 18	b	1.0
					+ 17		
X Her (100)							
155947	C 298	2388	....	M6	− 93	a	1.5
5.8–7.2	304	2389	....	6	− 92	a	1.5
	γ 9054	2392	....	6	− 91	a	1.5
	10130	2806	....	6	− 89	a	1.5
					− 91		

TABLE 2—*Continued*

Star, Period, Designation, Magnitude	Plate	JD 242	Phase	Spectrum	Vel.	Disp.	Wt.
			days		km/sec		
ST Her (167)							
154748	C 297	2387	....	M7	− 33	a	1.5
6.8–8.5	γ21859	9413	....	7	− 23	b	1.0
					− 29		
UW Her (229)							
171036	C 5189	5754	102	M5	− 13	b	1.0
7.5–8.5	5490	6165	55	5	− 15	b	1.0
	γ17635	6198	88	5	− 24	b	1.0
					− 17		
CX Her (90)							
170627	C 6223	7135	....	M6	− 24	b	0.3
7.8–8.8	7278	9379	....	7	− 42	b	1.0
	γ21864	9414	....	7	− 48	b	0.3
	C 7349	9471	....	7	− 46	b	1.0
					− 42		
Z Leo (57)							
094627	C 2044	3423	23	M4	− 22	b	0.7
8.6–10.0	4769	5364	34	3	− 24	b	0.7
	γ17308	6044	33	3	....	b	0.0
	C 5454	6111	43	2	+ 6	b	0.3
	5633	6313	17	3	− 22	b	1.0
	5661	6339	44	3	− 16	b	1.0
	γ18073	6401	50	3	− 25	b	0.7
	C 5714	6459	51	3	− 9	b	1.0
					− 17		
RY Leo (155)							
095814	γ19427	7080	....	M3e	+ 37	c	0.4
9.1–10.0	21276	8910	....	2e	+ 16	c	0.6
	C 5157	8936	....	3	+ 11	c	0.2
					+ 22		
S Lep (96)							
0601*24*	C 7254	9292	....	M5	+ 16	b	1.0
6.0–8.0	γ23326	0069*	....	5	+ 8	b	1.0
					+ 12		
V Lyn (87)							
062061	C 2048	3423	....	M6	− 43	b	0.3
8.6–9.8	5406	6046	....	6	− 28	b	0.3
	5908	6649	....	6	− 25	b	1.0
					− 29		
SZ Lyr (133)							
183146	C 7090	8733	55	M6	....	c	0.0
10.5–12.5	7295	9393	48	6	− 33	c	0.2
	7308	9411	66	6	− 35	c	0.4
	γ23330	0070*	57	6	− 49	c	0.4
	E 89	0090*	78	6	− 85	c	0.6
	305	0296*	17	6	− 49	c	0.2
					− 54		

TABLE 2—*Continued*

Star, Period, Designation, Magnitude	Plate	JD 242	Phase	Spectrum	Vel.	Disp.	Wt.
			days		km/sec		
XY Lyr (—)							
183439	γ22558	9736	....	M4	− 25	a	1.5
5.8–6.8	22591	9764	....	4	− 12	a	1.0
					− 20		
RT Mon (115)							
080310	C 5947	6726	33	M5	....	b	0.0
8.5–9.3	7275	9379	34	5	....	c	0.0
	γ22391	9644	69	4	+ 45	b	1.0
	C 7451	9670	95	3	+ 42	b	1.0
					+ 44		
SW Mon (110)							
062105	γ19272	7023	....	M5	+ 42	b	0.7
9.1–10.6	23311	0032*	....	5	+ 34	c	0.4
					+ 39		
BQ Ori (129)							
055122	C 7253	9292	....	M6	+ 22	b	0.7
7.4–8.9	γ23244	9974	....	5e	+ 37	b	1.0
					+ 31		
DP Ori (—)							
055610	γ23138	9928	....	M7	− 11	c	0.6
8.6–11.2	C 7651	0002*	....	7	− 8	c	0.6
					− 10		
ST Peg (136)							
224426	γ18903	6879	105	M6	+ 4	b	1.0
8.3–9.4	C 7551	9855	13	6	− 2	b	1.0
					+ 1		
TT Peg (158)							
000126	C 7154	8850	19	M6e	− 29	b	0.3
9.0–10.3	E 42	9896	114	6	− 34	b	0.6
					− 32		
TW Peg (90)							
215927	γ11283	3298	....	M7	− 33	a	1.5
6.5–9.2	11313	3325	....	6	− 23	a	0.5
	11994	3634	....	6	− 12	a	0.5
					− 27		
TX Peg (132)							
221313	C 7065	8702	11	M6e	+ 12	b	1.0
8.5–9.2	7134	8831	8	6	+ 13	b	1.0
	7135	8831	8	6	+ 10	b	1.0
					+ 12		
UW Peg (106)							
221302	γ21161	8734	....	M5	+ 28	c	0.6
8.7–9.7	C 7331	9440	....	5	+ 21	b	1.0
					+ 23		

TABLE 2—*Continued*

Star, Period, Designation, Magnitude	Plate	JD 242	Phase	Spectrum	Vel.	Disp.	Wt.
			days		km/sec		
AF Peg (52)							
224617	C 4963	5492	24	M6	− 44	b	1.0
8.9–9.9	5259	5817	34	6	− 40	b	1.0
	5512	6199	50	6	− 40	b	0.3
					− 42		
BC Peg (100)							
223620	γ19770	7287	37	M6	− 12	c	0.6
7.8–8.5	21206	8765	15	6	− 20	c	0.4
	22759	9824	74	6	− 10	c	0.6
					− 13		
BD Peg (—)							
223827	C 7089	8732	....	M6	− 9	b	1.0
6.8–7.8	γ21264	8881	....	6	− 21	b	1.0
	21375	9147	....	6	+ 10	b	0.7
	23818	0280*	....	6	− 25	c	0.6
					− 12		
BI Peg (120)							
225217	γ19771	7287	3	M6	− 19	c	0.6
8.0–8.8	21374	9147	63	6e	− 20	b	1.0
					− 20		
RS Per (—)							
021556	C 2536	3742	....	M4	− 36	b	1.0
8.0–9.4	2633	3803	....	4	− 39	b	0.3
	2672	3829	....	4	− 41	b	0.3
					− 38		
RU Per (181)							
032339	E 46	9897	12	M7	− 35	c	0.6
9.5–10.5	62	9913	28	6e	− 43	c	0.6
					− 39		
SU Per (116)							
021556	C 2535	3742	....	M4	− 39	b	1.0
7.4–8.4	2632	3803	....	4	− 39	b	1.0
	2671	3829	....	3	− 44	b	0.7
	γ17724	6221	....	3	− 36	b	1.0
	18050	6373	....	4	− 43	b	1.0
	C 5899	6646	....	4	− 34	b	1.0
					− 39		
SW Per (83)							
040441	C 5005	5519	15	M6	+ 52	b	1.0
8.2–9.8	7641	9971	68	5	+ 57	b	1.0
					+ 54		
TT Per (91)							
014453	C 7099	8763	9	M6	− 3	c	0.6
8.0–9.2	γ23310	0032*	89	6	− 5	c	0.6
					− 4		

TABLE 2—*Continued*

Star, Period, Designation, Magnitude	Plate	JD 242	Phase	Spectrum	Vel.	Disp.	Wt.
			days		km/sec		
UZ Per (90)							
031331	γ22472	9678	....	M5	− 8	c	0.6
7.8–9.0	C 7660	0029*	....	5	+ 10	c	0.6
					+ 1		
AA Per (130)							
030846	C 6963	8422	11	M6	+ 21	c	0.6
9.2–10.3	7659	0029*	50	6	+ 14	c	0.4
					+ 18		
AD Per (—)							
021356	C 1974	3358	....	M2	− 34	a	1.0
7.7–8.4	2124	3475	....	3	− 45	a	1.0
	5689	6373	....	2	− 51	b	0.7
					− 43		
RW Psc (100)							
011821	E 45	9897	....	M3	+ 6	c	0.6
9.1–10.3	60	9913	....	3	− 6	c	0.6
					0		
T Sge (157)							
191717	γ22561	9738	....	M4	+ 7	b	1.0
8.3–9.5	C 7487	9765	....	3	+ 2	b	1.0
					+ 4		
SU Sgr (88)							
185722	γ18367	6553	77	M6	+ 41	b	1.0
8.3–8.5	21861	9413	33	6	+ 44	b	1.0
					+ 42		
AX Sco (—)							
163526	C 7463	9705	....	M6	....	b	0.0
7.1–8.1	7486	9765	....	6	− 50	b	0.3
	7504	9806	....	6	− 40	c	0.6
					− 45		
Y Ser (385)							
150801	C 5192	5755	65	M5	− 67	b	1.0
8.0–9.1	7320	9439	284	5	− 51	b	1.0
					− 59		
Z Ser (88)							
151002	γ17425	6104	10	M5	− 26	b	0.3
9.4–10.4	18806	6814	20	5	− 32	b	0.3
	C 6047	6880	86	5	− 16	b	0.3
					− 25		
TV Tau (120)							
040226	γ21439	9176	66	M6	+ 82	c	0.2
10.9–11.7	23162	9945	115	6	+ 62	c	0.6
	E 315	0297*	107	6	+ 68	c	0.4
					+ 67		

TABLE 2—*Continued*

Star, Period, Designation, Magnitude	Plate	JD 242	Phase	Spectrum	Vel.	Disp.	Wt.
			days		km/sec		
TX Tau (84)							
040226	C 5591	6281	17	M5	− 13	c	0.4
10.6–12.3	7445	9669	45	5	− 20	b	0.7
					− 17		
W Tri (148)							
023534	γ22099	9505	....	M5	+ 12	c	0.6
8.2–9.0	23145	9932	....	5	+ 2	b	1.0
	23195	9957	....	5	+ 6	b	1.0
					+ 6		
V UMa (207)							
090151	γ22556	9736	206	M5	− 13	c	0.2
9.6–11.2	22587	9764	27	5	− 34	c	0.6
	C 7645	9972	27	6	− 42	c	0.6
	7652	0003*	58	5	− 33	c	0.6
	γ23328	0069*	124	5	− 43	c	0.4
					− 35		
RY UMa (41)							
121561	C 5176	5729	18	M3	− 9	a	1.5
7.2–8.3	γ21965	9450	12	2	− 13	b	1.0
	22475	9678	33	3	− 11	b	1.0
					− 11		
RZ UMa (136)							
080165	γ20679	7791	....	M5	− 33	c	0.6
8.8–10.2	21277	8911	....	6	− 36	c	0.6
					− 34		
ST UMa (81)							
112245	C 7251	9290	....	M5	− 10	a	1.5
6.5–7.3	γ21790	9381	....	5	− 24	a	1.5
	C 7297	9409	....	5	− 15	a	1.5
	7302	9410	....	5	− 16	b	1.0
					− 16		
R UMi (326)							
163172	γ12875	4014	208	M7	....	b	0.0
8.6–10.5	14175	4631	173	7	− 22	b	1.0
	21966	9450	102	7e	− 22	b	1.0
					− 22		
RT Vir (—)							
125705	C 296	2387	....	M8	+ 21	a	1.0
8.0–9.0	γ 9051	2391	....	8	....	a	0.0
	C 9298	5757	....	8	+ 6	b	1.0
	γ22476	9679	....	8	+ 11	b	1.0
					+ 13		
SW Vir (—)							
130802	C 302	2388	....	M7	− 11	a	1.0
6.8–8.1	γ 7299	9409	....	7	− 19	b	1.0
					− 15		

TABLE 2—*Continued*

Star, Period, Designation, Magnitude	Plate	JD 242	Phase	Spectrum	Vel.	Disp.	Wt.
			days		km/sec		
W Vul (239)							
200525	γ20789	7971	113	M5	+ 51	b	1.0
8.8–10.2	23133	9927	21	6	+ 48	b	1.0
					+ 50		

NOTES TO TABLE 2

Bright lines are mentioned in order of their intensity on the spectrograms.

RU And. Max. = JD 2429377 + 231ᵈ2 E, Schneller, *Catalogue*, 1939. $H\delta$ and $H\gamma$ are fairly strong bright lines on plate E318. E61 and E250 show very faint emission lines. C7216 and C7658 are weak and do not definitely prove the absence of emission. This star has a large magnitude range but considerable irregularity in period and light-variation.

RV And. A single Harvard observation, M3e, *Harvard Ann.*, **79**, 196, 1928.

TV And. $H\delta$, $H\gamma$, $H\zeta$, and $H\eta$ are fairly strong bright lines on plate γ22857. C7517 shows very faint bright $H\delta$ and $H\gamma$.

TY And. $H\delta$, $H\gamma$, $H\zeta$, $H\beta$, $H\eta$, and λ 3905 *Si* I are fairly strong bright lines on plate γ23134. γ22994 shows faint bright $H\delta$, $H\zeta$, and λ 3905 *Si* I. Two of four Harvard plates have hydrogen emission, *Harvard Ann.*, **79**, 204, 1928.

RU Aqr. Max. = JD 2415601 + 68ᵈ7E, Ryves, *M.N.*, **92**, 132, 1932. One of two Harvard plates has hydrogen emission, *Harvard Ann.*, **79**, 204, 1928.

TW Aqr. Max. = JD 2425103 + 79^d E, Schneller, *Catalogue*, 1939.

WX Aql. Max. = JD 2423210 + 105^d E, Leiner, *A.N. Beob.-Zirk.*, **4**, 51 (No. 29), 1922.

KN Aql. Max. = JD 2426153 + 139^d E, Schneller, *Catalogue*, 1939. Very faint bright $H\delta$ shows on the second plate, which was taken shortly before predicted maximum.

NO Aql. Max. = JD 2428419.2 + 63^d E, Schneller, *Catalogue*, 1939. Very faint bright $H\delta$ shows on plate γ23205. This star resembles the RV Tauri stars in some respects.

RV Boo. Very faint bright $H\delta$ shows on three plates. One of five Harvard exposures has bright hydrogen, *Harvard Ann.*, **79**, 200, 1928. λ 4226 *Ca* I is strong on the first two and the last plates.

RX Boo. Faint hydrogen lines, together with fairly strong λ 3905 and λ 4102 *Si* I, show in emission on the second plate. λ 4102 is stronger than $H\delta$.

RS Cnc. McLaughlin reports that bright lines appear during increasing light and weaken before maximum. Emission was found to be strongest in cycles when the light-variation was greatest. The light-elements Min. = JD 2425351 + 239^d E were determined. The maximum velocity of recession occurred one-fourth period after light-minimum. A mean velocity of +12.8 km/sec with a range of 6 km/sec was found. *Pub. Univ. of Michigan*, **8**, 118, 1941.

RT Cnc. Max. = JD 2426756 + 94ᵈ4 E, Schneller, *Catalogue*, 1939. The variation in type and velocity are apparently real.

VY CMa. This star, HD 58061 = ADS 6033 A, is imbedded in bright nebulosity, which possibly is responsible for the emission lines of hydrogen. It is described by Perrine, *Pub. A.S.P.*, **35**, 233, 1923. Several near-by companions or nuclei are recognized by double-star observers. M-type stars are not usually connected with nebulosity. The variation in light may well be of a nature very different from the other stars in this list. The emission lines are on the red edge of moderately strong absorption lines of hydrogen, which are displaced an angstrom or more toward the violet. The aluminum band head near $H\beta$ is unusually strong.

UX CMi. Max. = JD 2425370 + 151^d E, Schneller, *Catalogue*, 1939.

UY Cas. Max. = JD 2419328 + 102ᵈ5 E, Schneller, *Catalogue*, 1939. Fairly strong bright $H\beta$, $H\gamma$, $H\delta$, and $H\zeta$ show on the second and third plates.

SS Cep. Max. = 2425779.5 + 97ᵈ5 E, Schneller, *Catalogue*, 1939.

T Cet. Boss 60. Bright $H\beta$, $H\gamma$, and $H\delta$ show on the second and third plates. $H\beta$ is remarkably strong for a type so late, and the decrement is steep. The variation in velocity is probably real.

RR CrB. Max. = JD 2426148 + 56ᵈ8 E, Schneller, *Catalogue*, 1939.

S Crt. Two Harvard observations of type are M7e and M6e, *Harvard Ann.*, **79**, 199, 1928.

RZ Cyg. Max. = 2429516 + 546^d E, Schneller, *Catalogue*, 1939. In this peculiar star high and low maxima alternate. The light-curve resembles that of R Cen. The magnitude range is large for variables without bright lines.

AB Cyg. Observed maximum on JD 2426310 and JD 2427711, Loreta, *A.N.*, **261**, 263, 1936. Of three Harvard exposures, one shows bright lines, M4e, *Harvard Ann.*, **79**, 204, 1928.

AF Cyg. The light-curve is sometimes of the RV Tau type. McLaughlin reports bright lines, *Pub. A.A.S.*, **8**, 15, 1933. The phases are taken from O'Connell's observed maxima, *Harvard Bull.*, No. 888, 1933. There is some correlation of velocity with phase.

AI Cyg. Max. = JD 2420080 + 140^d E, Schneller, *Catalogue*, 1939.

BC Cyg. R. F. Sanford found that this red star is M-type and not N as suggested in Schneller's *Catalogue*. The star is located in an obscured region, and the spectra are markedly weak in the violet. The nature of its variation is not known.

CH Cyg. Boss 4966. Max. = 2422991 + 100^{d}6 E, Schneller, *Catalogue*, 1939.

TT Dra. Max. = 2424727 + 107^{d}4 E, Schneller, *Catalogue*, 1939.

TX Dra. Max. = 2425267 + 134^d E, *Harvard Ann.*, **79**, 175, 1928. Very faint bright $H\delta$ and $H\gamma$ show on the last plate.

UU Dra. Max. = JD 2418745 + 234^{d}4 E, *Harvard Ann.*, **79**, 190, 1928.

UV Dra. Max. = JD 2424436.4 + 77^{d}4 E, Schneller, *Catalogue*, 1939.

RW Eri. Max. = JD 2416780 + 91^{d}4 E, Schneller, *Catalogue*, 1939.

Y Gem. Strong bright $H\beta$ and weak $H\gamma$ show on the second plate. The decrement is steep, and $H\delta$ is not seen. One of three Harvard exposures has bright lines, M6e, *Harvard Ann.*, **79**, 198, 1928.

X Her. McLaughlin reports bright hydrogen lines at or just before maximum, *Pub. A.A.S.*, **7**, 94, 1932.

UW Her. Max. = JD 2419011 + 229^d E, *Harvard Ann.*, **79**, 176, 1928. One of two Harvard exposures has bright hydrogen lines, M4e, *Harvard Ann.*, **79**, 201, 1928.

Z Leo. Max. = JD 2424592.2 + 56^{d}77 E, Schneller, *Catalogue*, 1939.

RY Leo. Fairly strong bright $H\beta$, $H\gamma$, and $H\delta$ show on the first and second plates. The decrement toward the violet is gradual.

S Lep. Type Me, Gaposchkin and Gaposchkin, *Variable Stars*, 1938.

SZ Lyr. Max. = JD 2424410 + 133^{d}4 E, Schneller, *Catalogue*, 1939.

RT Mon. Max. = JD 2424618 + 115^{d}3 E, Schneller, *Catalogue*, 1939.

BQ Ori. Fairly strong bright $H\beta$, $H\gamma$, $H\delta$, and $H\zeta$, together with λ 3905 *Si* I, show on the second plate.

ST Peg. Max. = JD 2424562 + 115^{d}3 E, Schneller, *Catalogue*, 1939. One of two Harvard plates shows bright lines, M6e, *Harvard Ann.*, **79**, 204, 1928.

TT Peg. Max. = JD 2419321 + 158^{d}5 E, *Harvard Ann.*, **79**, 163, 1928. Faint bright $H\delta$ and $H\gamma$ show on the first plate.

TX Peg. Max. = JD 2423804 + 132^d E, Schneller, *Catalogue*, 1939. Faint bright $H\delta$ and $H\gamma$ show on the first plate.

AF Peg. Max. = JD 2423006 + 52^{d}4 E, Schneller, *Catalogue*, 1939.

BC Peg. Max. = JD 2426650 + 100^d E, Schneller, *Catalogue*, 1939.

BI Peg. Max. = JD 2426565 + 120^d E, Schneller, *Catalogue*, 1939. Faint bright $H\delta$ shows on the second plate.

RS Per, SU Per, and AD Per. Members of the double cluster (*h* and χ Per). The mean parallax of the cluster determined from the spectroscopic absolute magnitudes of the three stars, neglecting absorption in space, is 0″00073.

RU Per. Max. = JD 2416814 + 180^{d}7 E, Schneller, *Catalogue*, 1939. Fairly strong bright $H\delta$, $H\gamma$, $H\zeta$, and λ 3905 *Si* I show on the second plate.

SW Per. Max. = JD 2419362 + 83^d E, *Harvard Ann.*, **79**, 165, 1928.

TT Per. Max. = JD 2423721.5 + 91^{d}5 E, Schneller, *Catalogue*, 1939.

AA Per. Max. = JD 2424890 + 130^{d}4 E, Schneller, *Catalogue*, 1939.

SU Sgr. Max. = JD 2416620 + 88^d E, Schneller, *Catalogue*, 1939.

Y Ser. Max. = JD 2419145 + 385^d E, *Harvard Ann.*, **79**, 174, 1928. Two of six Harvard plates show $H\gamma$ and $H\delta$ faintly bright, *Harvard Ann.*, **79**, 200, 1928.

Z Ser. Max. = JD 2423204.3 + 87^{d}57 E, Schneller, *Catalogue*, 1939.

TV Tau. Max. = JD 2425870 + 120^d E, Schneller, *Catalogue*, 1939.

TX Tau. Max. = JD 2419384 + 80^d E, *Harvard Ann.*, **79**, 165, 1928.

V UMa. Min. = JD 2429530 + 207^{d}5 E, Schneller, *Catalogue*, 1939. Faint bright lines are suspected on Harvard plates, *Harvard Ann.*, **79**, 198, 1928.

RY UMa. Min. = JD 2429894 + 41^{d}42 E, Schneller, *Catalogue*, 1940. One of six Harvard plates shows bright hydrogen lines, M4e, *Harvard Ann.*, **79**, 199, 1928.

R UMi. Min. = JD 2429348 + 326^d E, Nielsen, *A.N.*, **270**, 42, 1940. Faint bright $H\delta$ and $H\gamma$ show on the third plate.

W Vul. Max. = JD 2417017 + 238^{d}7 E, *Harvard Ann.*, **79**, 189, 1928. One Harvard exposure shows bright lines, M4e. *Harvard Bull.*, **79**, 203, 1928.

TABLE 3

ABSOLUTE MAGNITUDES AND VELOCITIES OF IRREGULAR M-TYPE VARIABLES

Star	l	b	m_v at Max.	Spec. M_v	π_{sp} Unit=0″001	Spec.	Velocity		Period
							Meas.	Residual	
							km/sec	km/sec	days
RU And	101°	−23°	10.0	−0.6	0.8	M5e–6e	− 42	− 41	231
RV And	104	−11	8.7	−0.3	1.6	5	− 10	− 9	229
SS And	76	− 7	8.9	−1.3	0.9	5 –6	− 22	− 12	160
TV And	70	−16	8.8	−0.5	1.4	4e–5e	− 50	− 40	114
TY And	72	−19	8.2	−0.9	1.5	5e–6e	− 6	+ 3	150
TZ And	81	−14	8.5	−0.7	1.4	5 –6	− 31	− 23	280
RU Aqr	24	−69	9.0	−1.0	1.0	5 –6	+ 26	+ 27	69
TW Aqr	16	−31	9.3	−0.9	0.9	5 –6	− 38	− 26	79
BM Aqr	10	−51	9.0	−1.0	1.0	4 –5	− 21	− 15	......
TZ Aql	8	−25	8.5	−0.6	1.5	6	+ 50	+ 63	90
WX Aql	10	−12	8.8	−0.8	0.5	6	− 28	− 12	105
KN Aql	14	−22	7.7	−1.0	1.8	5e	−140	−125	139
LU Aql	20	− 4	9.2	−0.9	1.0	4	+ 2	+ 20	50
NO Aql	11	−11	9.9	−1.6	0.5	3 –4e	− 99	− 82	66
PX Aql	0	−20	9.2	−0.6	1.1	5	− 35	− 21	......
TU Aur	138	+18	7.7	−0.9	1.9	5	+ 8	+ 3	75
UX Aur	128	+ 7	8.0	−1.3	1.4	5	+ 34	+ 30	90
UZ Aur	135	+ 2	7.7	−1.0	1.8	4	+ 21	+ 24	66
RV Boo	18	+65	7.6	−0.9	2.1	5 –6e	− 3	+ 11	138
RW Boo	16	+65	7.3	−0.7	2.5	5	− 11	+ 3	373
RX Boo	1	+68	7.0	−0.6	3.0	7 –8e	− 10	+ 3	78
RR Cam	108	+21	9.2	−0.5	1.1	6	− 61	− 56	123
RS Cam	101	+33	8.1	−0.4	2.0	5 –6	− 41	− 34	89
RV Cam	117	+ 7	7.9	−1.0	1.7	5 –6	− 21	− 21	103
RY Cam	112	+12	8.0	−0.7	1.8	3 –4	− 23	− 21	135
Z Cnc	177	+28	8.5	−0.5	1.6	6 –7	+ 4	− 8	80
RS Cnc	163	+43	5.3	−1.5	4.4	5 –6	+ 11	+ 5	239
RT Cnc	186	+34	7.3	−1.3	1.9	5 –6	+ 36	+ 25	94
RV CMa	194	− 3	8.9	−0.9	1.1	6	+ 27	+ 8	......
VY CMa	206	− 4	7.8	−2.9	0.7	3e–4e	+ 49	+ 30	......
UX CMi	183	+16	8.5	−1.2	1.1	5	+ 25	+ 10	151
UY Cas	77	− 2	9.6	−1.1	0.7	3e–4e	− 4	+ 7	102
VY Cas	90	0	9.0	−0.6	1.2	6	− 92	− 85	100
SS Cep	97	+21	6.7	−1.1	2.7	6	− 41	− 34	98
μ Cep	68	+ 4	4.0	−4.5	2.0	2	+ 20	+ 34	......
T Cet	54	−80	5.2	−1.8	4.0	5e	+ 29	+ 27	160
Y CrB	27	+51	9.8	−0.4	0.9	8	− 20	− 3	300
RR CrB	27	+52	7.2	−0.5	2.9	5	− 50	− 33	57
RU CrB	7	+52	8.8	−0.9	1.1	5	− 27	− 10	436
X Crv	271	+44	7.8	−1.2	1.6	6	+ 1	+ 1	127
S Crt	248	+53	8.4	−1.1	1.3	6	+ 32	+ 30	152
RZ Cyg	54	+ 1	9.6	−1.4	0.6	7	− 47	− 31	546
AB Cyg	49	−16	7.7	−0.7	2.1	4 –5	− 7	+ 7	482
AF Cyg	45	+12	6.4	−0.8	3.6	6	− 15	+ 3	94
AI Cyg	41	− 5	8.4	−0.8	1.4	6	− 58	− 41	140

TABLE 3—*Continued*

Star	l	b	m_v at Max.	Spec. M_v	π_{sp} Unit=0″.001	Spec.	Velocity Meas.	Velocity Residual	Period
							km/sec	km/sec	days
BC Cyg	43°	0°	9.8	−1.8	0.5	M3 –4	− 3	+ 15	......
CH Cyg	49	+15	6.4	−1.4	2.7	6	− 53	− 35	101
U Del	30	−17	5.6	−2.0	3.0	5	− 21	− 5	......
S Dra	50	+40	7.5	−1.0	2.0	6	+ 6	+ 23	......
SS Dra	93	+49	8.6	−1.1	1.1	5	+ 33	+ 43	48
SZ Dra	63	+22	8.0	−1.2	1.4	5	− 42	− 26	120
TT Dra	52	+35	8.5	−0.9	1.3	6	− 23	− 6	107
TX Dra	56	+40	6.8	−1.9	1.8	4e–5	+ 52	+ 68	134
UU Dra	75	+20	8.7	−0.2	1.7	8	− 37	− 21	234
UV Dra	61	+55	8.8	−1.1	1.0	5	− 35	− 21	77
Z Eri	157	−57	6.4	−0.9	3.5	5	− 14	− 27	......
RW Eri	166	−34	8.6	−1.0	1.2	6	+107	+ 90	91
Y Gem	168	+21	8.5	−0.7	1.4	6e	+ 18	+ 6	......
TV Gem	157	+ 3	7.0	−3.1	1.0	2	+ 17	+ 4	......
η Gem	157	+ 4	3.3	−0.9	14.5	3	+ 19	+ 7	......
X Her	40	+47	5.8	−1.1	4.2	6	− 91	− 74	100
ST Her	42	+49	6.8	−0.7	3.2	7	− 29	− 12	167
UW Her	27	+34	7.5	−1.3	1.7	5	− 17	+ 2	229
CX Her	16	+32	7.8	−0.5	2.2	7	− 42	− 22	90
α Her	3	+26	3.1	−2.2	8.7	5	− 33	− 14	......
g Her	33	+43	4.4	−1.0	8.3	6	+ 3	+ 22	......
Z Leo	174	+52	8.6	−0.6	1.4	2 –4	− 17	− 22	57
RY Leo	192	+50	9.1	−0.9	1.0	2e–3e	+ 22	+ 15	155
S Lep	198	−19	6.0	−1.3	3.5	5	+ 12	− 8	96
V Lyn	121	+22	8.6	+0.1	2.0	6	− 29	− 29	87
R Lyr	41	+17	4.0	−1.1	9.6	5	− 28	− 9	......
SZ Lyr	42	+21	10.5	−0.8	0.5	6	− 54	− 35	133
XY Lyr	35	+18	5.8	−2.6	2.1	4	− 20	− 1	......
RT Mon	199	+13	8.5	−0.9	1.3	3 –4	+ 44	+ 27	115
SW Mon	173	− 2	9.1	−0.5	1.2	5	+ 39	+ 22	110
BQ Ori	155	0	7.4	−0.4	2.7	5e–6	+ 31	+ 18	129
CI Ori	172	−17	4.7	+0.1	12.0	0	+ 8	− 10	......
DP Ori	166	− 5	8.6	−0.4	1.6	7	− 10	− 26	......
α Ori	167	− 7	0.1	−4.1	14.5	2	+ 21	+ 5	......
SX Pav	290	−39	5.3	....	....	6	+ 43	+ 37	......
ST Peg	60	−29	8.3	−1.4	1.1	6	+ 1	+ 9	136
TT Peg	79	−35	9.0	−1.5	0.8	6e	− 32	− 28	158
TW Peg	51	−23	6.5	−0.9	3.3	6 –7	− 27	− 15	90
TX Peg	44	−36	8.5	−0.4	1.7	6e	+ 12	+ 22	132
UW Peg	34	−44	8.7	−1.4	1.0	5	+ 23	+ 31	106
AF Peg	55	−37	8.9	−1.3	0.9	6	− 42	− 34	52
BC Peg	55	−33	7.8	−1.1	1.7	6	− 13	− 3	100
BD Peg	59	−28	6.8	−0.8	3.0	6	− 9	+ 1	......
BI Peg	57	−38	8.0	−1.0	1.6	6e	− 20	− 12	120
RS Per	103	− 4	8.0	−2.6	0.8	4	− 38	− 35	......

TABLE 3—*Continued*

STAR	l	b	m_v AT MAX.	SPEC. M_v	π_{sp} UNIT = 0".001	SPEC.	VELOCITY Meas.	VELOCITY Residual	PERIOD
							km/sec	km/sec	days
RU Per......	121°	−13°	9.5	−1.3	0.7	M6e–7	− 39	− 43	181
SU Per......	103	− 4	7.4	−3.5	0.7	3 –4	− 39	− 36	116
SW Per......	126	− 7	8.2	−1.0	1.4	5 –6	+ 54	+ 49	83
TT Per......	100	− 8	8.0	−0.9	1.7	6	− 4	− 1	91
UZ Per......	125	−21	7.8	−1.5	1.4	5	+ 1	− 5	90
AA Per......	115	− 9	9.2	−1.8	0.6	6	+ 18	+ 16	130
AD Per......	103	− 3	7.7	−3.1	0.7	2 –3	− 43	− 40	......
ρ Per......	117	−16	3.2	−0.9	15.1	4	+ 28	+ 25	......
RW Psc......	102	−40	9.1	−2.0	0.6	3	0	− 2	100
TV Psc.....	84	−44	5.2	−1.4	4.8	3	+ 5	+ 7	......
T Sge.....	19	0	8.3	−2.3	0.8	3 –4	+ 4	+ 23	157
SU Sgr......	342	−14	8.3	−0.8	1.5	6	+ 42	+ 54	88
AX Sco.....	322	+12	7.1	−0.8	2.6	6	− 45	− 35	......
α Sco.....	320	+14	0.9	−3.7	12.0	1	− 3	+ 7	......
Y Ser......	327	+44	8.0	0.0	2.5	5	− 59	− 47	385
Z Ser......	331	+46	9.4	−1.1	0.8	5	− 25	− 12	88
TV Tau.....	137	−18	10.9	−0.7	0.5	6	+ 67	+ 58	120
TX Tau.....	137	−18	10.6	−0.8	0.5	5	− 17	− 26	84
W Tri......	116	−22	8.2	−0.7	1.7	5	+ 6	+ 2	148
V UMa....	135	+43	9.6	−0.4	1.0	5 –6	− 35	− 36	207
RY UMa....	96	+57	7.2	−0.5	2.9	2 –3	− 11	− 2	41
RZ UMa....	118	+34	8.8	−1.2	1.0	5 –6	− 34	− 32	136
ST UMa....	127	+67	6.5	−1.3	2.7	5	− 16	− 12	81
R UMi....	71	+36	8.6	−0.3	1.7	7e	− 22	− 8	326
V UMi....	85	+43	7.5	−0.5	2.5	4	−165	−154	70
RT Vir......	281	+67	8.0	0.0	2.5	8	+ 13	+ 18	......
SW Vir......	284	+59	6.8	−1.0	2.7	7	− 15	− 11	......
W Vul.....	32	− 5	8.8	−0.8	1.2	5 –6	+ 50	+ 68	239

Figure 1 shows the galactic distribution of the stars of Table 3. The center of the figure represents longitude 90° and latitude 0°. The scarcity of stars in the general direction of the center of the galaxy at longitude 325° is probably without significance. This region may have been somewhat neglected on account of its southern declination. In longitude the greatest density is in the region between 40° and 120°, but this concentration may be the result of selection.

Apparent magnitude.—In order to be comparable with the general practice for Me stars, the maximum apparent brightness has been used. Photographic magnitudes have been reduced to visual by the appropriate correction for color index, 1.7 mag. The average magnitude range is 1.3 mag., which is much smaller than that of the Mira variables.

Spectroscopic absolute magnitudes.—For the determination of absolute magnitude by the Mount Wilson spectroscopic method the reduction tables used in 1935[7] were employed without change. The zero point for the normal giants is fairly well determined, but for the supergiants the calibration is less certain on account of the lack of suitable standards. Distinct supergiant characteristics are shown by 13 stars (μ Cep, α Ori, α Sco SU Per, TV Gem, AD Her, VY CMa, XY Lyr, RS Per, T Sge, α Her, RW Psc, U Del),

[7] *Mt. W. Contr.*, No. 511; *Ap. J.*, **81**, 187, 1935.

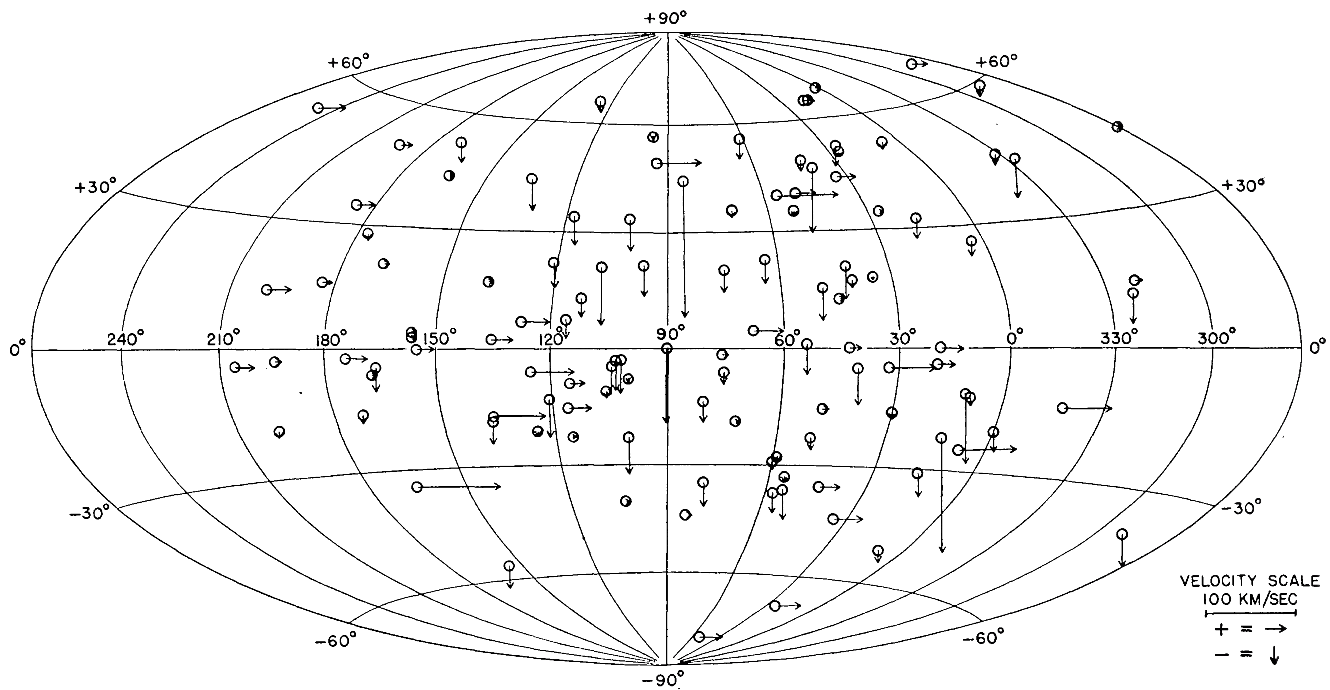

FIG. 1.—Galactic distribution and residual radial velocities of irregular M-type variables. The horizontal arrows indicate positive velocities; the vertical arrows, negative.

whose absolute magnitudes range from -4.5 to -2.0. The remainder of the variables are normal giants with a dispersion of about 1 mag. from the mean absolute magnitude of -0.9. This mean corresponds closely with -1.0 found by Wilson and Merrill[8] for the Me variables. Figure 2 shows the distribution of absolute magnitudes. The stars are mainly concentrated in the giant group, and the scattered supergiants are compara-

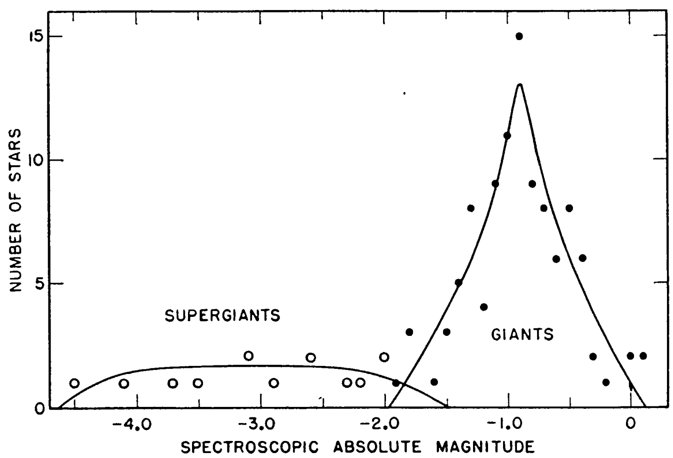

FIG. 2.—Distribution of absolute magnitudes of irregular M-type variables

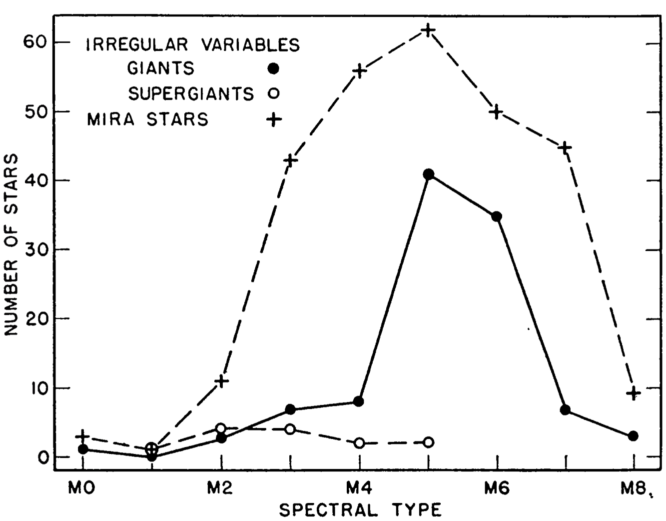

FIG. 3.—Distribution of spectral type among the irregular M-type variables. Merrill's estimates of the Mira stars are included for comparison.

tively few. Numerical values of the relative percentage in each group cannot be given until the effect of selection is known, but it seems clear that about nine-tenths of the irregular M-variables belong to the normal giant group and that their luminosities are much the same as those of the Mira variables.

Spectral type.—As shown in Figure 3, the irregular variables are predominantly of spectral types M5 and M6. Two-thirds of the observed stars fall in these two classes. As compared with the long-period variables,[9] the maximum frequency is at about the

[8] *Mt. W. Contr.*, No. 658; *Ap. J.*, **95**, 255, 1942.

[9] Merrill, *Mt. W. Contr.*, No. 649; *Ap. J.*, **94**, 208, 1941.

same spectral type, but the irregular stars have a much greater concentration. Of the 13 supergiant irregular variables, 11 are M4 or earlier. The stars having emission lines show no preference for any particular type.

Although the full range in type during a cycle may not always be covered by the scattered observations, it is evident that the change is small. For 82 stars the estimates indicate no change in type; for 35, the variation, including the error of estimation, is only one subdivision of type; and for one star only, Z Leo, the difference in type amounts to as much as two subdivisions.

Radial velocities.—The velocities of Table 3 are the weighted means of the observed values for each star. The variation with phase is small compared with the errors of observation and may be neglected. In order to free the velocities from the effect of the

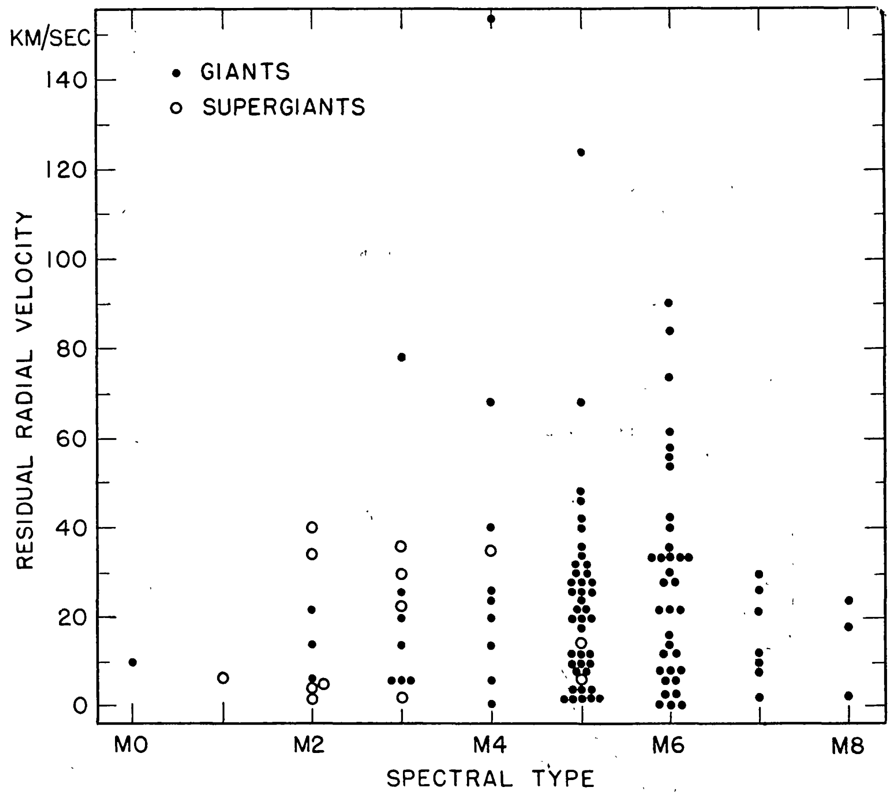

FIG. 4.—Residual radial velocity and spectral type for the irregular M-type variables

sun's motion relative to the near-by stars they have been corrected for a solar motion of 20 km/sec toward the usual apex, and the residual values are in the next to the last column. The direction and relative values of the residual velocities are displayed in Figure 1.

The average residual velocity for 118 irregular stars is 25.3 km/sec, which is definitely smaller than the value 36.1 km/sec found by Merrill[10] for the long-period variables. The average velocity for the 13 irregular supergiants is 18.2 km/sec and for 105 giants, 26.1 km/sec. The distribution of residual velocities with respect to spectral type is shown in Figure 4. The wide scatter of velocities in the earlier spectral types from M0 to M4, which was found for the long-period variables, is not present among the irregular stars, probably for the reason that there are few normal giants of early spectral types.

[10] *Mt. W. Contr.*, No. 649; *Ap. J.*, **94**, 209, 1941.

The mean residual velocities for the various spectral types appear in Table 4, where the number of stars in each group is in parenthesis.

The relationship between radial velocity and period is shown in the second half of the table, the individual values being plotted in Figure 5. The scatter in the residual

TABLE 4

RESIDUAL RADIAL VELOCITY AND DISPLACEMENT OF EMISSION LINES FOR DIFFERENT SPECTRAL TYPES AND PERIODS

Spectrum	Mean Residual Vel.	Displacement Abs.−Em.	Period	Mean Residual Vel.	Displacement Abs.−Em.
	km/sec	km/sec	days	km/sec	km/sec
M0–2	15(9)	+ 6.0(1)	41– 74	44(10)	+16 (1)
M3	23(11)	+ 8.0(2)	75– 99	25(33)	+ 8 (1)
M4	39(10)	+ 8.6(4)	100–124	31(18)	+ 7.5(2)
M5	23(43)	+ 5.8(5)	125–149	31(13)	+ 6.8(5)
M6	28(35)	+10.0(7)	150–199	20(10)	+ 8.8(5)
M7	17(7)	+12.0(1)	200–249	21(15)	+10.1(2)
M8	15(3)	+ 9.0(1)	>250	....	+12 (1)
Mean	25.3(118)	+ 8.9(21)	Mean	27.7(89)	+ 8.9(17)

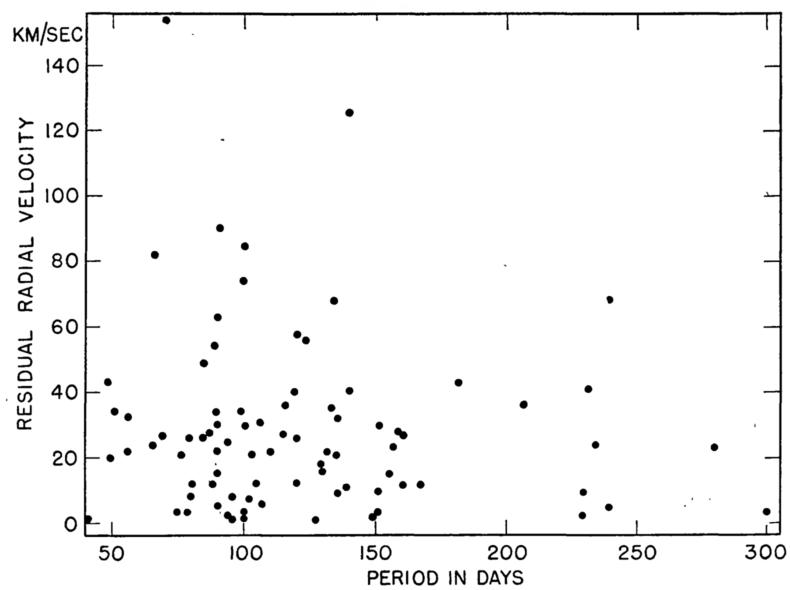

FIG. 5.—Residual radial velocity and period

velocities is greater among the stars having shorter periods. A similar correlation was obtained by Merrill from the Mira stars, although the periods involved are very different.

Displacements of emission lines.—Emission lines of hydrogen were measured in 17 stars. Their displacements, which are toward the violet with reference to the absorption lines, are listed in Table 5. The means for various spectral types and periods are given in Table 4, where the number of stars used in the mean is given in parenthesis. In Figures

TABLE 5

DISPLACEMENT OF EMISSION LINES

Star	Spec.	Period	No. Lines	Abs.−Em.	Star	Spec.	Period	No. Lines	Abs.−Em.
		days		km/sec			days		km/sec
RU And.....	M6e	231	3	+15	T Cet....	M5e	160	2	+ 8
	M5e		2	+ 8	TX Dra....	M4e	134	2	+13
TV And.....	M4e	114	2	+ 5	Y Gem...	M6e	....	2	+15
TY And.....	M5e	150	4	+ 6	RY Leo....	M3e	155	2	0
KN Aql.....	M5e	139	1	+ 3		M2e		2	+ 6
NO Aql.....	M4e	66	1	+16	BQ Ori....	M5e	129	4	+ 4
RV Boo.....	M6e	138	1	+ 8	TT Peg....	M6e	158	2	+21
RX Boo.....	M8e	78	3	+ 8	TX Peg....	M6e	132	2	+ 6
RS Cnc.....	M6e	239	21	+ 8.7*	RU Per....	M6e	181	2	+ 6
UY Cas.....	M3e	102	2	+16	R UMi...	M7e	326	2	+12
	M4e		2	+ 4					

* McLaughlin, *Pub. Obs. Univ. of Michigan,* **8,** 120, 1941.

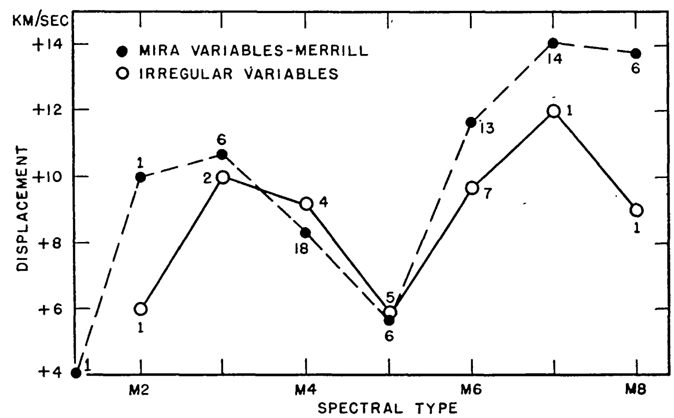

FIG. 6.—Spectral type and relative displacement (*A–E*) of emission in M-type variables. The number of stars in each normal point is indicated.

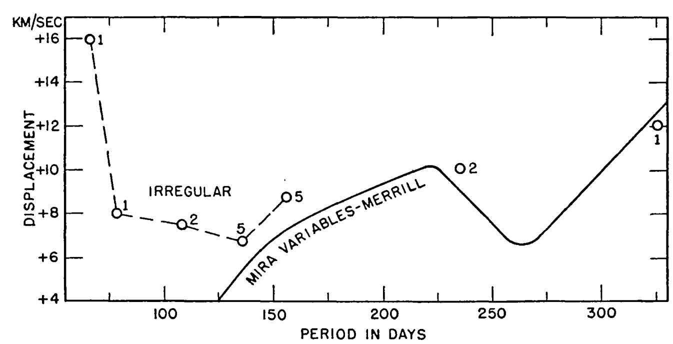

FIG. 7.—Period and relative displacement (*A–E*) of emission in M-type variables. The number of stars in each normal point is indicated for the irregular variables. Merrill's curve for the Mira stars is shown.

6 and 7 these values are plotted, together with the comparable mean displacements determined by Merrill[11] for the long-period variables. Although the material is rather limited, there is a striking similarity in the two groups, especially in the correlation between displacement of the bright lines and spectral type. The displacement seems to be more intimately related to spectral type or temperature than to other parameters, such as period, range, and regularity of light-changes.

Correlations with period.—For variable stars in general the period of variation is a definite and fundamental parameter to which other characteristics may be referred, but

TABLE 6

DISTRIBUTION OF PERIODS OF 89 OBSERVED STARS

Period	No.	Period	No.
days		days	
40– 59	6	160–179	3
60– 79	8	180–199	1
80– 99	19	200–219	1
100–119	14	220–239	6
120–139	15	240–299	1
140–159	8	>300	7

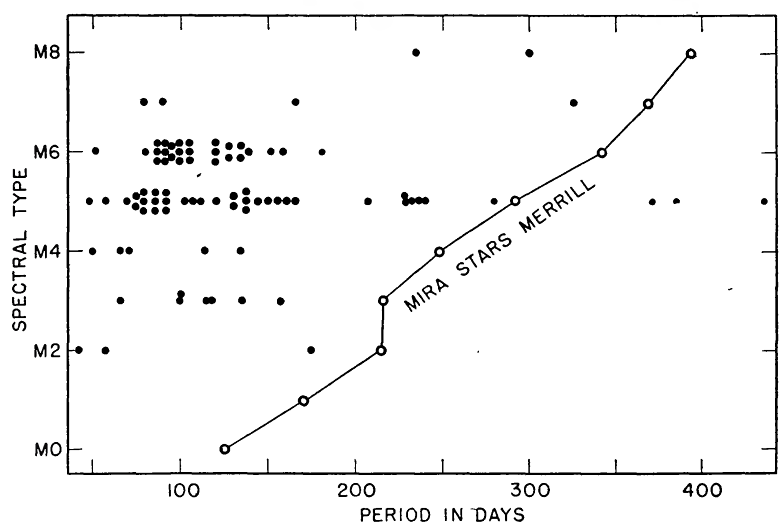

FIG. 8.—Spectral type and period of M-type variables observed at Mount Wilson. The normal points for Merrill's Mira stars, grouped according to type, are plotted.

for causes at present not fully understood periodicities in the less regular variables are followed in a loose and uncertain fashion. In some stars there may be a multiplicity of cycles which overlap one another and thus conceal the underlying periodicities. The period which has been assigned to the irregular M-type stars by the variable-star observers is usually a mean of the intervals between maxima or minima which may differ greatly in magnitude. The ingenuity of the observers in deducing periods from the observations is most commendable, but it should be kept in mind that the periods determined for stars considered in this paper have quite a different significance from the periods of the Mira stars or the Cepheids.

The periods for 89 of the stars observed are distributed as shown in Table 6. The greatest frequency lies between 80 and 140 days, with a mean at 108 days.

[11] *Mt. W. Contr.*, No. 644; *Ap. J.*, **93**, 383, 1941.

There are also 15 stars with periods between 200 and 546 days, with a secondary frequency maximum at 233 days. Few supergiants are included because their light-changes are too irregular to justify the assignment of periods. Of the giants, the stars with periods between 40 and 200 days have slightly fainter absolute magnitudes, somewhat earlier spectral types, and residual radial velocities which are 8 km/sec greater in the mean than those of the stars with longer periods. It is probable that the variables with periods shorter than 200 days are considerably different in nature from those with longer periods.

In Figure 8, spectral type is plotted against period for the irregular stars, and the corresponding mean values for the Mira variables[12] are included for comparison. The lack of agreement between the two groups is very striking. Later spectral type goes with longer period in both groups, but in the irregular variables the periods are of an entirely different order from those of the Mira stars. In the irregular stars the higher harmonics of the cycle appear to be enhanced, but in the Mira stars the fundamental period with its greater regularity prevails and induces a greater range in luminosity and temperature.

CARNEGIE INSTITUTION OF WASHINGTON
MOUNT WILSON OBSERVATORY
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[12] Merrill, *Mt. W. Contr.*, No. 649; *Ap. J.*, **94**, 199, 1941.