COMPARISON BETWEEN SPECTRAL-LUMINOSITY CLASSES ON THE MOUNT WILSON AND MORGAN-KEENAN SYSTEMS OF CLASSIFICATION*

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Abstract

Regression tables are presented for stars classified on both the Mount Wilson and Morgan-Keenan systems. These tables serve to show that a Morgan-Keenan spectral-luminosity class can be estimated from a Mount Wilson type to within two spectral sub-classes and to within one half a luminosity class.

Sommaire

Des tables de régression sont présentées pour étoiles classifiées dans les systèmes Mount Wilson et Morgan-Keenan. Ces tables servant à montrer qu'une classe spectrale et qu'une classe de luminosité Morgan-Keenan peuvent être déduites d'une classification Mount Wilson au moins á deux sous-classes spectrales et au moins à une demie classe de luminosité.

For a number of applications it is useful to know the relationship between the various systems of spectral-luminosity classification. Fehrenbach (1958) made an extensive study of the relationships between several such systems. However, it appears that no study has been published on the correlation between the Mount Wilson (MtW) and Morgan-Keenan (MK) systems of classification.

In order to make such a study, those stars having spectral-luminosity classifications on both the MK and MtW systems, based on slit spectra, are compared. The stars are chosen from the Jaschek, Conde, and Sierra catalogue of spectral types (1964) for the MK spectra, and the Mount Wilson radial velocity catalogue for the MtW spectra. Some MK types also are taken from the photoelectric catalogue of Blanco and FitzGerald (McCuskey 1966). A total of 2764 stars fulfilling these requirements is found.

Regression tables and averages, prepared from the data, are presented in Tables I to IV. Table I contains only those stars assigned both luminosity class d on the MtW system and V on the MK system. Similarly, the regression tables for sub-giants (sg and IV), giants (g and III), and supergiants (c and II, Ib, Iab, or Ia) form the major part of Tables II to IV respectively. Certain late K sub-classes, which are unrepresented in the sample, have been omitted from the tables.

*Contributions of the University of Waterloo Observatory, no. 2.

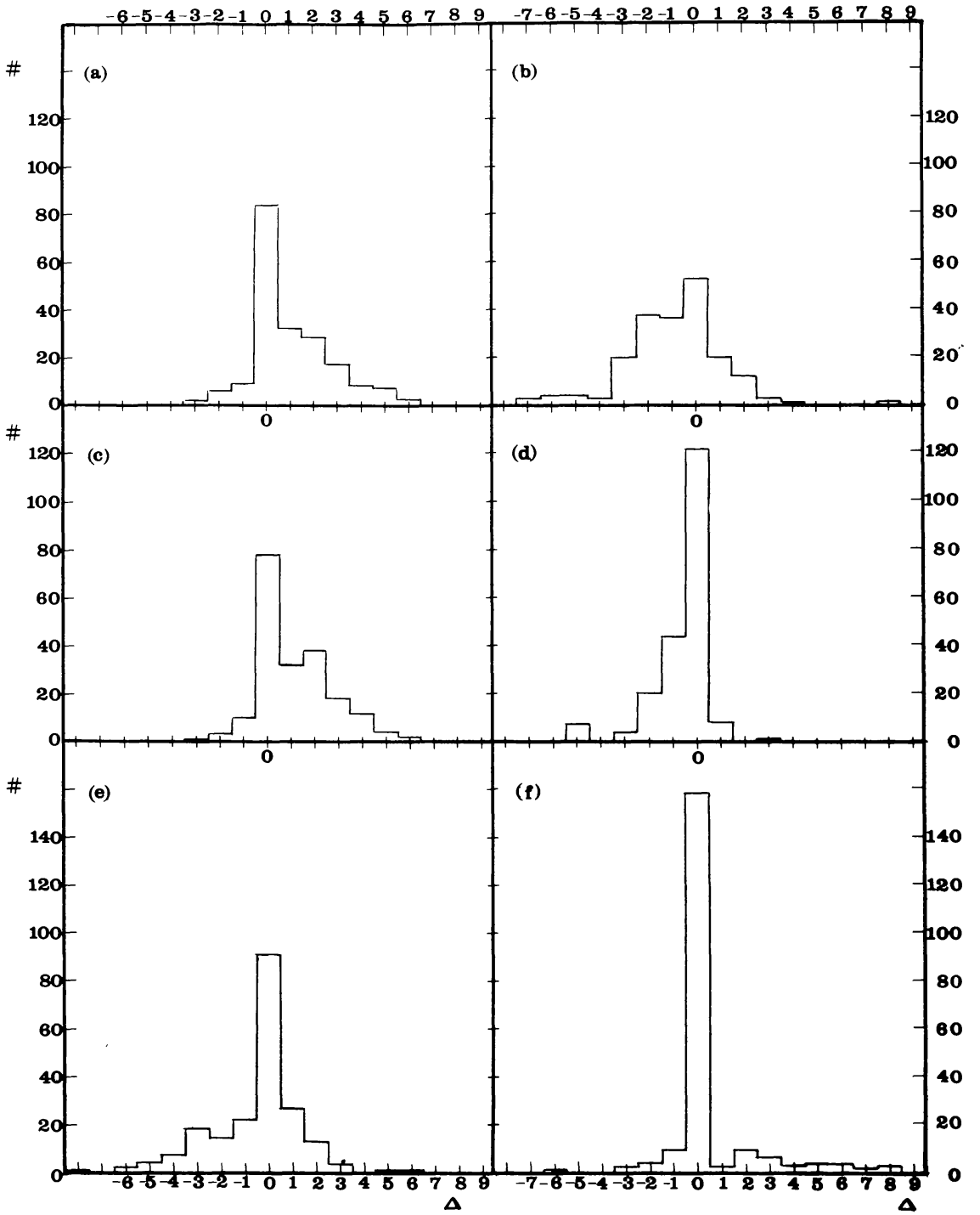

FIG. 1—Histograms of the difference, △; [(observed MK spectral type) — (given MtW spectral type)] for six spectral-luminosity groupings: (a) dA5 – dG7, 871 stars; (b) dG8 – dM5, 150 stars; (c) gA5 – gK2, 755 stars; (d) gK3 – gM6, 530 stars; (e) cO9 – cM5, 209 stars; (f) sgA5 – sgM3, 233 stars.

Each histogram is normalized to 200 stars.

All data are averaged for a given spectral-luminosity class in one system to give a mean value in the other system. The averages include all assigned classifications on the one system for a given class on the other, and are

Morgan - Keenan (columns) vs. Mount Wilson Class d (rows)

Mt W. d	A0	1	2	3	4	5	6	7	8	9	F0	1	2	3	4	5	6	7	8	9	G0	1	2	3	4
A5				2	1	4		2	1		5	1													
6								3	1	3	1		1												
7								2		1	2		1	3											
8									1	1	4	1	1												
9								1		1		1	1												
F0						1			1		19		3	2	2										
1										1	1	12	7	4	1	2									
2										1	3		20	9	1	3									
3												1		24	2	10	7								
4														3	31	18	16	2	4	1					
5														1	2	38	12	8	5	4	1				
6																	42	7	5	4	2				
7																	4	35	9	4	3	2	1		
8																			28	3	8		2	1	
9																			4	19	6	1	3	1	
G0																		1	3	2	30	4	12	2	
1																					4	14	11		1
2																			1		4	5	11	4	2
3																					3	2	1	4	2
4																							2		7
5																							4		1
6																									1
7																									1
8																									
9																									
K0																									
1																									
2																									
3																									
4																									
5																									
6																									
M0																									
1																									
2																									
3																									
4																									
Tot #			2	2	1	5		10	5	8	35	16	34	46	40	71	81	54	59	37	62	28	48	12	15
Average Lum			3.6	5.0		5.0		4.6	4.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Average Sp			A2.0	A5.0		A6.0		A5.9	A7.8	A8.1	A9.0	F0.4	F1.1	F2.2	F3.7	F4.2	F5.2	F6.3	F7.4	F7.9	F9.3	G0.8	G1.1	G1.4	G3.9

Class V (columns) vs. Mount Wilson Class d (rows)

Mt W. d	G5	6	7	8	9	K0	1	2	3	4	5	7	M0	1	2	3	4	5	Tot #	Average Sp	Average Lum	Most Likely
A5																			18	A7.2	4.8	F0V
6																			13	A8.5	4.5	F0V
7																			13	F0.9	4.7	F0V
8																			11	F0.2	4.5	F0V
9																			7	F0.4	4.4	F0V
F0																			34	F0.9	4.6	F0V
1																			35	F2.0	4.7	F1V
2																			46	F2.5	4.7	F2V
3																			56	F4.1	4.7	F3V
4																			89	F5.1	4.8	F4V
5																			85	F6.0	4.8	F5V
6																			65	F6.7	4.9	F6V
7																			63	F7.8	4.9	F7V
8																			45	F8.9	4.9	F8V
9																			39	F9.7	4.8	F9V
G0	2																		60	G0.6	4.9	G0V
1	3	1																	36	G1.9	4.9	G1V
2	3		1																35	G2.5	4.8	G2V
3	4	1		2															22	G3.7	4.8	G5V
4	6	2	1	2															25	G4.8	4.7	G5V
5	13			7		3													32	G6.3	4.8	G5V
6	4	3	2	7		4													23	G7.0	4.7	G8V
7	3		2	4	1	2	3												20	G8.1	4.7	G8V
8	1			10		7													21	G8.6	4.8	G8V
9		1		2	1	1	1	1	1										11	G9.6	4.6	G8V
K0				6	1	6	4												21	G9.6	4.9	G8-K0V
1				3	1	7	6	1											18	K0.1	5.0	K0V
2						4	4	3											12	K0.8	4.9	K0V
3							3	1	1										5	K1.6	5.0	K1V
4							1	1	2	1	1								6	K3.0	5.0	K3V
5						1	2	5	8	1	4								21	K2.9	5.0	K3V
6						1		2	2	1	7	2		1					17	K4.3	4.9	K3V
M0											1	3	5	1					10	K8.3	5.0	M0V
1											1	1	1		1				4	K8.5	5.0	V
2														1	2		1		4	M2.2	5.0	M2V
3														1		1	1		3	M2.8	5.0	V
4																						
Tot #	39	8	6	43	4	36	24	14	14	4	14	6	6	4	3	1	2					
Average Lum	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0					
Average Sp	G4.2	G5.0	G5.4	G7.2	G9.2	G9.3	K1.1	K3.6	K4.4	K5.0	K6.2	K8.8	M0.2	M0.2	M1.7	M3	M2.5					

TABLE I—Regression table and average spectral-luminosity types for stars classed d and V.

shown at the margins of the regression tables. In order to form mean spectral-luminosity types it is assumed that both the spectral and luminosity classes are continuous sequences. For this purpose each of the MK and MtW luminosity classes are assigned a decimal value as shown in Table V.

As an example of the data presented, consider the stars classified gK4 on the MtW system, shown in Table III. Of the 94 stars assigned this class, six are MK class K2 III; twenty-three, K3 III; forty-three, K4 III; and a further sixteen have luminosity classes other than III. The latter do not appear in the regression table but are included in the averages. The total number of gK4 stars, their average MK type, that is K3.6 and luminosity class 2.9, are shown in the right-hand margin. The most frequently occurring spectral and luminosity classes, K4 and III respectively, appear in the last column. Similarly, of the 84 stars classified K4 III, one is assigned MtW type gK1; two, gK2; three, gK3; forty-three, gK4; thirty-three, gK5; one, gK6; one, gM0; and none with other MtW luminosity classes. The average MtW type is K4.3, luminosity class 3.0.

It should be emphasized that regression lines obtained by finding a mean MtW class for a given MK class are different from those obtained by determining a mean MK class for a given MtW class. The unbiased relationship involving the two systems lies between the two regression lines and is not determined. The reader is referred to the papers by Fehrenbach (1964) and Junkes (1952) for a discussion of this problem. The regression lines do not differ by more than 0.5 spectral sub-classes for most types between F1 V and M3 V, F0 IV and G2 IV, G9 IV and K4 IV, A6 III and F8 III, and G8 III and M6 III. The largest differences occur for spectral classes that are not well represented among the 2764 stars.

Table VI contains the weighted average standard deviations from the mean MK class, when estimated from the MtW class, for several spectral-luminosity groupings. Also given is the standard deviation of the average. The MK spectral class of a star may be estimated from its assigned MtW type to within 0.5 sub-classes at best, and two sub-classes at worst. The luminosity class can be estimated to within 0.5 classes except for the cO9 – cA9 stars.

Morgan - Keenan

Mount Wilson Class sg	A0	1	2	3	4	5	6	7	8	9	F0	1	2	3	4	5	6	7	8	9	G0	1	2	3	4
A5																									
6																									
7								1																	
8								1																	
9										1															
F0											11														
1												4													
2													13												
3														19											
4															20										
5																22									
6																	15								
7																		11							
8																									
9																				1					
G0																					3				
1																						3			
2																							5		
3																								3	
4																									3
5																									
6																									
7																									
8																									
9																									
K0																									
1																									
2																									
3																									
4																									
5																									
6																									
M0																									
1																									
2																									
3																									
4																									
5																									
6																									
Tot #								3		1	21	4	21	20	26	35	19	15	8	2	7	6	8	5	3
Average Lum								3.3		4	4.5	4.0	4.4	4.1	4.2	4.4	4.3	4.3	5.0	3.5	4.6	4.5	4.4	4.4	4.0
Average Sp								A7.0		A9	A9.2	F1.0	F1.9	F3.0	F4.0	F4.1	F5.8	F6.3	F6.4	F9.5	G0.1	G0.5	G1.8	G1.6	G1.0

Class IV

Mount Wilson Class sg	G5	6	7	8	9	K0	1	2	3	4	5	7	M0	1	2	3	4	5	Tot #	Average Sp	Average Lum	Most Likely
A5																			3	A9.0	4.3	
6																			2	F3.0	4.0	
7																			5	A8.6	4.0	
8																			3	F0.0	3.8	
9																			1	A9	4	
F0																			11	F0.0	4.0	F0 IV
1																			5	F1.1	3.6	F1 IV
2																			14	F2.2	3.9	F2 IV
3																			19	F3.0	4.0	F3 IV
4																			21	F4.0	4.1	F4 IV
5																			23	F4.9	4.0	F5 IV
6																			15	F6.0	4.0	F6 IV
7																			11	F7.0	4.0	F7 IV
8																						
9																			1	F9	4	F9 IV
G0																			4	G0.0	4.2	G0 IV
1																			3	G1.0	4.0	G1 IV
2	1																		8	G3.9	3.7	G2 IV
3																			5	G4.8	3.6	G3 IV
4	1			2															6	G8.2	3.9	G4 IV
5	3			1															6	G6.0	3.5	G5 IV
6		1		2	1														6	G8.2	3.9	G6 IV
7			2	1															7	G8.1	3.3	G7 IV
8			1	2		1													9	G8.8	3.4	G8-K0 IV
9						1													3	K3.3	3.3	K0 III
K0				1		9	2												22	K0.2	3.6	K0 IV
1							8												18	K0.9	3.6	K1 IV
2						2	1	2											9	K1.3	3.5	K2 IV
3																			5	K2.8	3.0	K3 IV
4										1									2	K3.5	3.5	
5								1											1	K2	4	
6																						
M0																			1	K4	3	
1																						
2																						
3																1			1	M3	4	
4																			1	M4	3	
5																						
6																			1	M5	3	
Tot #	7	2	4	13	1	19	16	3		1						1						
Average Lum	4.6	4.5	4.2	4.2	4	4.2	3.9	4.0		4						4						
Average Sp	G3.8	G7.0	G6.5	G5.5	G6	G9.3	K0.8	K3.0		K4						M3						

TABLE II—Regression table and average spectral-luminosity types for stars classed sg and IV.

The data presented in Tables I to IV and VI show very strong correlation between the MtW and MK systems of spectral-luminosity classification. Usually the most frequently occurring MK luminosity classes for d, sg, g, and c on the MtW system are V, IV, III, and II or I respectively. Similarly the most frequently occurring MK spectral class for stars of a given MtW type is the MtW value itself. However, the mean MK spectral class is often not the same as the most frequently occurring one. This can be seen from Tables I to IV, but is more clearly illustrated in figure 1, which shows a histogram of the difference, Δ:

(observed MK spectral type) – (given MtW spectral type)

normalized to 200 stars for each of six spectral-luminosity groupings: (a) dA5–dG7, 871 stars; (b) dG8–dM5, 150 stars; (c) gA5–gK2, 755 stars; (d) gK3–gM6, 530 stars; (e) cO9–cM5, 209 stars; and (f) sgA5–sgM3, 233 stars. It is evident that the histograms for A to G dwarfs and giants, are significantly skew to the right, those for K and M, dwarfs and giants, significantly skew to the left. The subgiants and supergiants show no significant tendency toward a skew distribution. The presence of this distribution does not appear to be caused by a statistical effect, but is probably related to the criteria by which the stars were classified on the two systems.

In conclusion, the spectral-luminosity class on the Mount Wilson system serves a reasonable evaluation of that on the Morgan-Keenan system. The accuracy of an estimate of a spectral class ranges from 0.5 to 2 sub-classes, with the relationship between the systems appearing to be skew for the giants and dwarfs. The accuracy of an estimate of a luminosity class is within one half a class except for the early-type supergiants.

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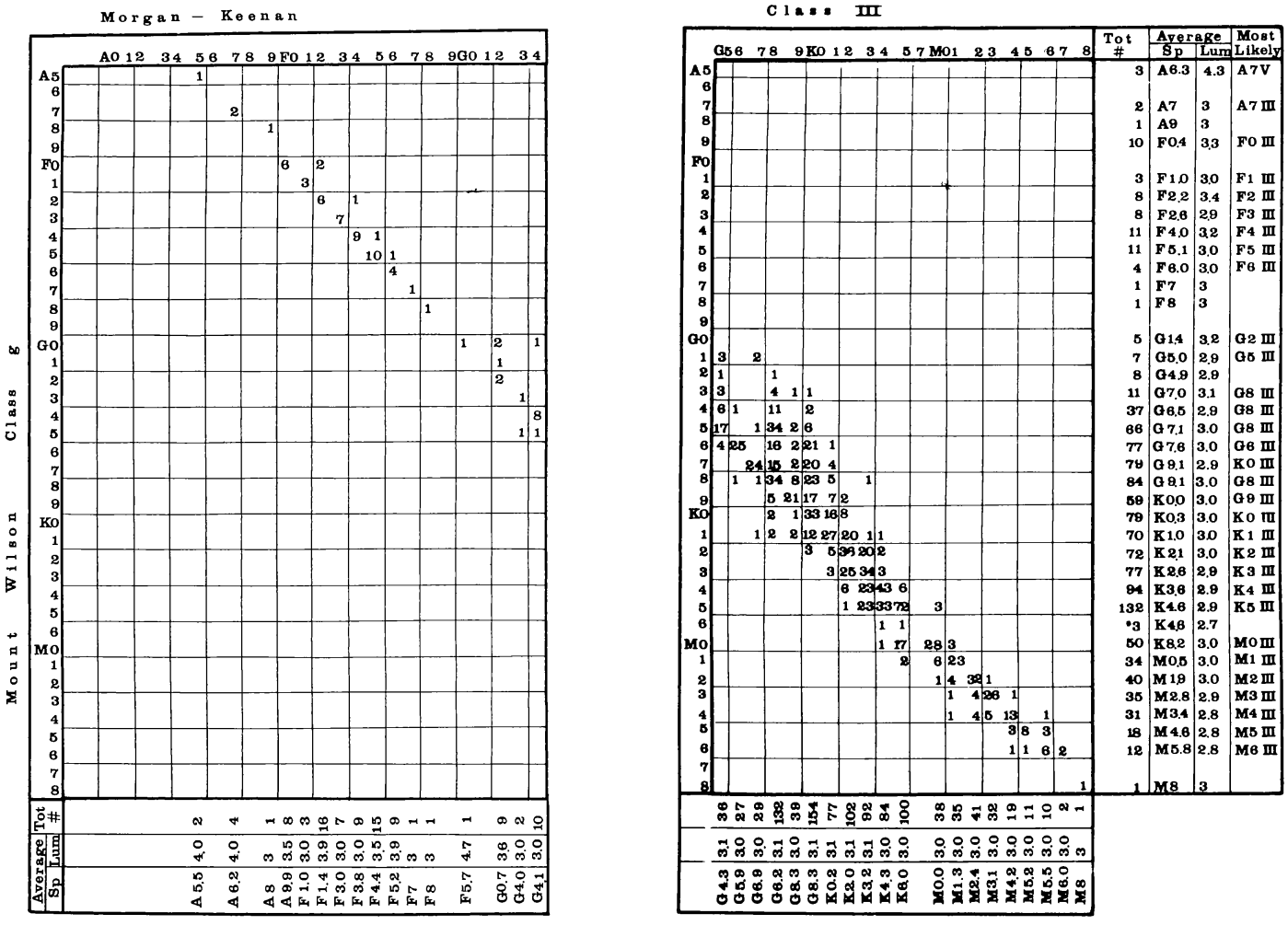

TABLE III—Regression table and average spectral-luminosity types for stars classed g and III.

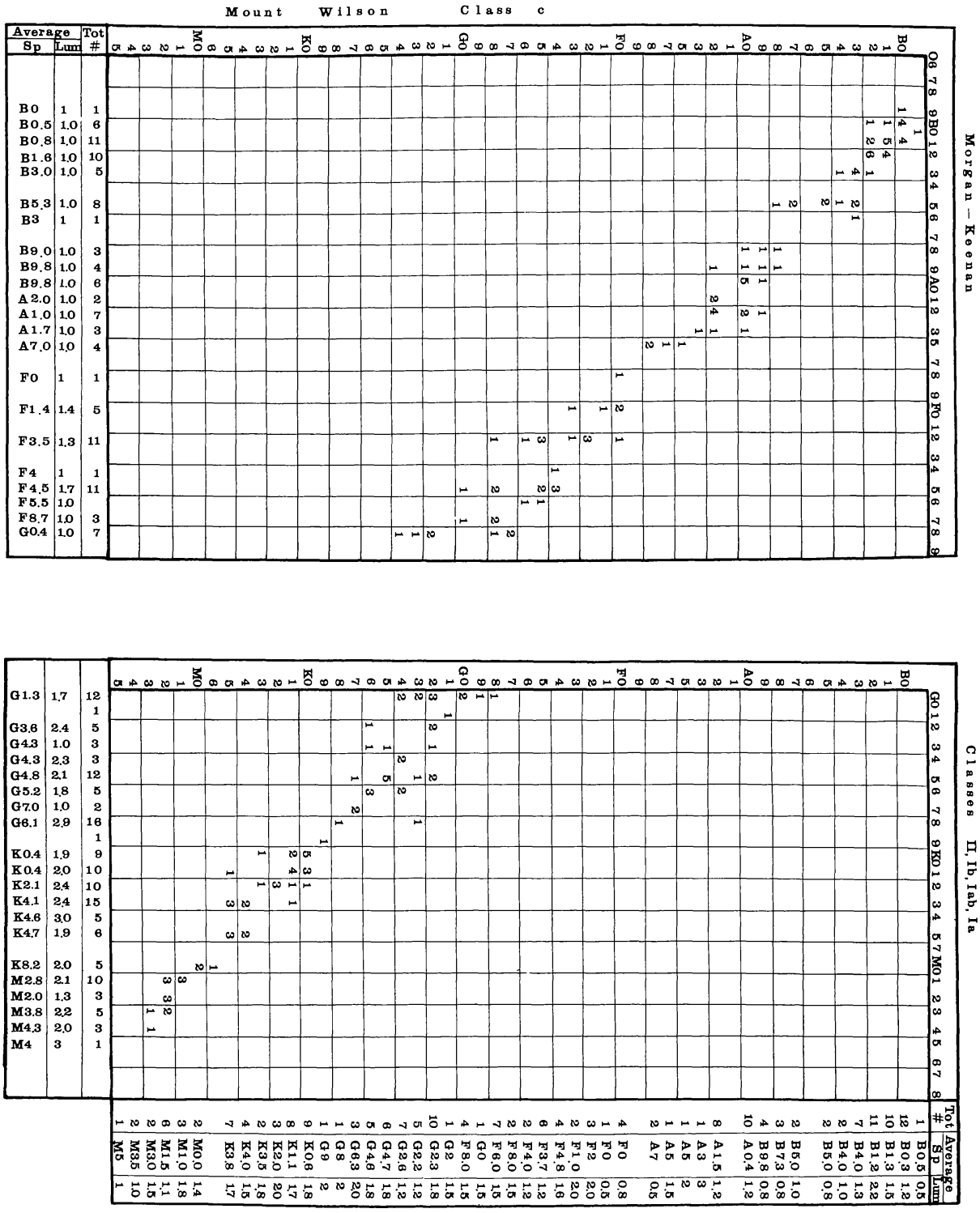

TABLE IV—Regression table and average spectral-luminosity types for stars classed c and II, Ib, Iab or Ia.

TABLE V

NUMERICAL VALUES ASSIGNED TO MK AND MtW LUMINOSITY CLASSES

MK Class	MtW Class	Numerical value	MK Class	MtW Class	Numerical value
V	d	5.0	II–III		2.5
IV–V		4.5	II		2.0
IV	sg	4.0	Ib		1.5
III–IV		3.5	Iab	c	1.0
III	g	3.0	Ia		0.5

TABLE VI

AVERAGE STANDARD DEVIATIONS FROM THE MEAN MK CLASS, AS ESTIMATED FROM THE ASSIGNED MtW CLASS

MtW Class	Spectral Class			Luminosity Class		
	Average s.d.		s.d. of average	Average s.d.		s.d. of average
dA5 – dG9	1.7	±	0.4	0.5	±	0.2
dK0 – dM3	1.6	±	0.6	0.0	±	0.2
sgF0–sgG1	0.2	±	0.3	0.2	±	0.2
sgG2–sgK4	1.3	±	1.4	0.5	±	0.2
gA5 – gF9	0.6	±	0.5	0.5	±	0.3
gG0 – gG7	1.9	1	0.2	0.3	±	0.1
gG8 – gM8	1.0	±	0.4	0.2	±	0.1
cO9 – cA9	0.9	±	0.5	0.8	±	0.4
cF0 – cG9	1.9	±	1.3	0.4	±	0.3
cK0 – cM6	0.8	±	0.6	0.3	±	0.2

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