A. Vibert Douglas

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SPECTROSCOPIC MAGNITUDES OF A-TYPE STARS

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Reprinted for private circulation from
THE ASTROPHYSICAL JOURNAL, Vol. LXIV, No. 4, November 1926
PRINTED IN THE U.S.A.

SPECTROSCOPIC MAGNITUDES OF A-TYPE STARS

By A. VIBERT DOUGLAS

ABSTRACT

A study of spectra of A-type stars has resulted in seven criteria being found by which absolute magnitudes and hence parallaxes may be determined. These criteria include both *widths* and *relative intensities* of *lines*. *Parallaxes* thus determined, when compared with trigonometric parallaxes and those from moving clusters and spectroscopic parallaxes from Mount Wilson and Arcetri, seem to indicate that a *greater individual accuracy* can be obtained by the use of such criteria than by adopting a statistical mean magnitude for each spectral subdivision.

INTRODUCTION

Absolute magnitudes of A-type stars have been determined spectroscopically at Mount Wilson, Arcetri, Upsala, and Yerkes observatories. Adams and Joy at Mount Wilson[1] and later Abetti at Arcetri[2] relied upon careful classification of the spectra into decimal subdivisions of class A and then the adoption of the statistical mean magnitude associated with each subclass. Lindblad[3] found that a comparison of the density of the regions λλ 3884–3907 and λλ 3907–3935 gave a correlation with absolute magnitude for stars of classes B8–A3. O. Struve[4] obtained relations between magnitude and the width of λ 4481 throughout the range of A stars.

During the summer of 1925, by the courtesy of the Director of the Yerkes Observatory, the writer was given the opportunity of making a study of the large collection of one-prism slit spectrograms of A stars taken with the Bruce spectrograph attached to the 40-inch refractor. The aim was to find several criteria for the determination of magnitude, and it was hoped that by the application of these a value of magnitude for a given star might be obtained upon which greater reliance might be placed than can be accorded to the average magnitude per spectral subclass.

[1] *Mt. Wilson Contr.*, No. 244; *Astrophysical Journal*, **56**, 242, 1922.

[2] *Pubblicazioni della R. Università degli Studi di Firenze*, No. 42, 1925.

[3] *Nova Acta Regiae Societatis Scientiarum Upsaliensis* (4), **6**, 5, 1925.

[4] Unpublished. See brief statement in *Abstracts of Theses, 1923–24*, "University of Chicago Science Series," **2**, 57, 1926.

CRITERIA

The spectral regions studied by Lindblad are beyond the range of good definition on the Yerkes plates, so that this criterion was inapplicable. The method of taking the relative intensities of certain arc and spark lines, used with such success by many investigators in the case of stars of later type, was an obvious line of attack. In A0 stars the number of absorption lines is very limited, and of these the number of known origin and series relation which are unblended is yet smaller, so that the choice of lines theoretically suitable is not great. The writer was guided less by theory than by appearances in selecting the ratios λ 4215:λ 4227, λ 4233:λ 4227, λ 4535:λ 4481, λ 4549:λ 4481. But the choice was justified, for in each case correlations were found to exist between these ratios and absolute magnitude.[1] The estimates of ratio of intensity were made by eye, a low-power magnifying lens being used. No attempt was made to record a factor indicative of the intensity of individual lines, the ratio of the intensities of the two closely adjacent lines being estimated directly in the case of each of the four pairs.

The second natural line of attack is that of line width. There are strong theoretical grounds, chiefly involving Rayleigh scattering, that lead one to anticipate relations between line width and absolute magnitude. The writer has found such correlations in the case of λ 4481, $H\delta$, and the K line of calcium.[2] There are intangible factors, such as Doppler effects arising from stellar rotation or from atomic agitation, which might conceivably play an important rôle in disturbing any general relation. It seems unlikely that the ambiguity involved in the writer's relations is due to these causes since exactly similar ambiguities are present in the correlations with intensity ratios. Reference will be made to this again.

The material upon which the criteria are based consists of spectrograms of thirty-one stars of the Ursa Major and Taurus clusters for which reliable parallaxes have been determined by Rasmusson,[3] and also of forty-nine stars having known trigonometric parallaxes. Relative to these eighty stars the systematic error of the absolute magnitudes determined from the writer's seven criteria is found to be −0.04 mag. and the probable error of an individual magnitude, ±0.5 mag.

[1] *Journal of the Royal Astronomical Society of Canada*, 20, 8, 1926. [2] *Ibid.*

[3] *Meddelanden från Lunds Astronomiska Observatorium*, Serie II, No. 26, 1921.

The spectra were all classified, as is done at Mount Wilson, according to the sharpness (s) or nebulosity (n) of the absorption lines and, provisionally, separate solutions were made for each group with respect to each of the seven criteria. In the case of $H\delta$, a strong correlation was found between its width and magnitude for the s group, but no correlation whatever was apparent in the case of the n group. For the other criteria both n and s groups yielded correlations. The ambiguity above referred to arises from the fact that not one of the criteria is single valued, the plotted data in each case falling into two or more groups, each of which could be fairly well represented by a linear solution. That this is the case both for the widths of absorption lines and for the ratios of intensities of pairs of lines points to some general complexity in the atmospheres of stars of class A.

MAGNITUDES AND PARALLAXES

By the application of the criteria above mentioned the absolute magnitudes and parallaxes of two hundred stars of classification B9–F0 have been determined from an investigation of the Yerkes spectrograms. These results are given in Table I, where for comparison, the corresponding values obtained by trigonometric, group motion, or Mount Wilson spectroscopic methods are also given. This number includes seventy-three of the eighty for which trigonometric or group parallaxes are known, and the probable error of ±0.5 mag. relative to these compares favorably with the probable error of ±0.4 mag. of the spectroscopic magnitudes of stars of later type as determined at Mount Wilson.

Among the two hundred stars are one hundred and eight whose absolute magnitudes have been determined at Mount Wilson. Comparison indicates that the writer's magnitudes are systematically less by 0.09 with a probable error of one difference of ±0.3. Another twenty-two stars not included above are found in the Arcetri list, and relative to these the writer's magnitudes show similar agreement—systematic error, −0.03; probable error, ±0.3.

In comparing the mean magnitude per spectral subclass, it should be remarked that the writer has not adopted the Henry

TABLE I

SPECTROSCOPIC MAGNITUDES AND PARALLAXES OF 200 A STARS

Boss	Name	H.D. m	Trig. or Gr.		Mt. Wilson			Douglas		
			M	p	Class	M	p	Class	M	p
10	α And	2.2	......	......	A1n	1.1	0".060	A1n	1.0	0".059
43	θ And	4.4	......	......	A1n	1.5	.026	A3n	1.7	.029
50	σ And	4.5	0.6	0".017T	A0n	1.1	.021	A0n	0.2	.014
145	π Cas	5.0	......	......	......	......	......	A1n	1.3	.018
154	+54°143	5.5	......	......	A2s	1.1	.014	A1s	0.9	.012
203	μ And	3.9	1.5	.033T	......	......	......	A6n	2.0	.042
246	41 And	5.2	......	......	......	......	......	A4n	2.2	.025
269	82 Psc	4.9	......	......	......	......	......	A4n	1.6	.022
295	89 Psc	5.3	......	......	A1n	1.5	.018	A2n	1.4	.017
300	υ Psc	4.7	0.9	.017T	......	......	......	A2n	2.3	.033
314	δ Cas	2.8	......	......	A3n	2.0	.068	A5n	2.5	.087
368	+42°345	5.5	......	......	......	......	......	A5n	2.5	.025
370	ω Cas	5.5	......	......	......	......	......	A2s	0.9	.012
422	γ Ari N	4.8	......	......	......	......	......	A0n	0.7	.015
423	γ Ari S	4.8	......	......	......	......	......	A2s	0.6	.014
428	β Ari	2.7	1.9	.068T	......	......	......	A5s	1.9	.069
441	λ Ari	4.8	2.1	.029T	......	......	......	A7n	2.1	.029
446	48 Cas	4.7	1.2	.020T	A4s	2.0	.029	A3n	2.0	.029
449	50 Cas	4.1	......	......	A1n	1.1	.025	A1s	1.2	.026
452	47 Cas	5.4	......	......	......	......	......	A1n	1.4	.016
463	α Psc Ft	5.2	......	......	A3n	1.8	.022	A3s	1.5	.018
463	α Psc Br	4.3	......	......	......	......	......	A3s	0.4	.017
466	ϵ Tri	5.4	......	......	A2n	1.5	.016	A1n	2.3	.024
476	κ Ari	5.1	......	......	......	......	......	A5s	1.9	.023
480	58 And	4.8	......	......	......	......	......	A1n	1.8	.025
482	β Tri	3.1	−0.7	.017T	......	......	......	A3s	1.3	.044
522	62 And	5.1	......	......	A1n	0.9	.014	A0n	0.3	.011
550	ι Cas	4.6	......	......	A3s	1.4	.021	A3s	2.0	.030
560	ξ Cet	4.3	......	......	......	......	......	A0n	0.8	.020
597	ν Ari	5.8	......	......	......	......	......	A2n	1.6	.014
606	33 Ari	5.4	−4.6	.001T	......	......	......	A1n	0.5	.010
628	38 Ari	5.2	......	......	......	......	......	A6s	2.4	.028
629	μ Cet	4.4	2.2	.036T	......	......	......	A7n	1.9	.032
666	−4°502	5.3	......	......	A0n	1.1	.014	A0n	1.2	.015
674	ϵ Ari Br	5.3	1.6	.018T	A3s	1.0	.014	A2s	1.2	.015
677	−3°470	5.2	......	......	......	......	......	A2n	1.1	.015
730	ζ Ari	5.0	......	......	......	......	......	A1n	0.9	.015
791	+54°684	5.0	......	......	A0n	0.9	.015	A0n	1.1	.016
850	+70°257	5.4	......	......	......	......	......	A4s	1.1	.014
883	+25°624	5.4	......	......	......	......	......	A3n	2.5	.026
923	τ^9 Eri	5.1	......	......	......	......	......	A1s	0.5	.012
932	ν Tau	3.9	......	......	......	......	......	A4s	1.0	.026
971	46 Tau	5.4	......	......	......	......	......	A8s	2.5	.026
974	+53°750	5.1	......	......	A1n	1.1	.015	A0n	1.2	.017
986	b Per	4.6	......	......	......	......	......	A0s	0.6	.016
998	56 Tau	5.3	......	......	......	......	......	A1s	0.3	.010
1007	58 Tau	5.3	2.4	.027G	A9n	2.8	.031	A6n	2.0	.022
1022	64 Tau	4.8	2.1	.029G	A6n	2.4	.034	A5s	2.0	.028
1023	66 Tau	5.1	......	......	A3n	2.0	.017	A2n	2.1	.025
1026	κ^1 Tau	4.4	1.3	.025G	A3s	1.8	.030	A2n	1.5	.026
1027	κ^2 Tau	5.4	2.8	0.030G	A3n	2.1	0.022	A1n	1.7	0.018

TABLE I—*Continued*

Boss	Name	H.D. m	Trig. or Gr.		Mt. Wilson			Douglas		
			M	p	Class	M	p	Class	M	p
1029	68 Tau	4.2	1.3	0".026G	A3s	1.4	0".028	A3s	1.7	0".032
1033	υ Tau	4.4	1.6	.028G	A2n	1.8	.030	A2n	......	......
1034	71 Tau	4.6	1.8	.028G	A0n	1.3	.022	A2n	......	......
1046	θ^2 Tau	3.6	0.7	.026G	A3s	1.6	.042	A5s	1.7	.042
1047	79 Tau	5.1	2.3	.028G	A2n	2.0	.024	A4n	2.1	.025
1051	80 Tau	5.7	2.8	.026G	A3n	2.1	.019	A3n	2.6	.024
1054	+15°637	4.8	2.1	.029G	A5s	2.0	.028	A5s	2.1	.029
1067	ρ Tau	4.8	1.9	.027G	A2n	2.0	.028	A2n	1.2	.019
1087	90 Tau	4.3	1.6	.028G	A3n	2.1	.036	A3n	1.8	.032
1088	51 Eri	5.3	......	......	A4s	2.0	.022	A6s	2.3	.025
1090	σ^2 Tau	4.9	1.6	.023G	A3n	2.2	.028	A3n	2.2	.029
1092	+7°681	5.6	2.3	.023G	A5s	2.2	.020	A5s	2.5	.024
1095	−12°955	5.0	......	......	A4s	1.7	.022	A3s	1.8	.023
1114	+10°621	5.4	2.6	.029G	A8s	2.6	.027	A5n	2.1	.022
1117	4 Cam	5.4	1.4	.016T	......	......	......	A7s	1.9	.020
1122	+11°646	5.4	1.9	.020G	A7s	2.2	.024	A6s	1.8	.019
1143	97 Tau	5.1	2.2	.026G	A2n	1.7	.021	A1n	1.7	.021
1153	ω Eri	4.5	......	......	......	......	......	A0n	1.9	.030
1194	ι Tau	4.7	1.6	.024G	A3n	2.1	.030	A4n	1.4	.022
1220	β Eri	2.9	0.5	.033G	A1n	1.5	.052	A0n	1.6	.055
1244	14 Aur	5.1	......	......	......	......	......	A7s	2.6	.032
1268	19 Aur	5.2	......	......	......	......	......	A6s	2.3	.026
1352	38 Ori	5.3	......	......	......	......	......	A0n	1.3	.016
1392	49 Ori	4.9	......	......	......	......	......	A0n	0.9	.016
1452	31 Cam	5.3	......	......	......	......	......	A1s	0.7	.012
1453	ξ Aur	4.9	......	......	A2s	1.4	.020	A1s	0.6	.014
1482	θ Aur	2.7	−0.9	.019T	A1s	0.6	.037	A1s	0.1	.030
1488	60 Ori	5.3	......	......	......	......	......	A0n	0.1	.009
1492	2 Mon	5.1	......	......	......	......	......	A7s	1.8	.022
1516	17 Lep	5.0	......	......	......	......	......	A6s	3.2	.044
1575	2 Lyn	4.4	1.5	.026T	A2s	1.2	.024	A1n	0.7	.018
1690	γ Gem	1.9	0.5	.053T	A2s	0.9	.063	A2s	0.3	.048
1714	26 Gem	5.1	......	......	......	......	......	A1n	1.4	.018
1716	12 Lyn	4.9	......	......	A1n	1.1	.014	A1n	1.1	.017
1759	36 Gem	5.2	......	......	......	......	......	A0s	0.4	.011
1763	θ Gem	3.6	0.4	.023T	......	......	......	A0n	0.5	.024
1782	−0°1487	5.3	......	......	......	......	......	A4n	1.7	.019
1853	22 Mon	4.1	......	......	......	......	......	A0n	0.5	.019
1886	λ Gem	3.6	1.5	.038T	A2n	1.5	.038	A2n	1.8	.044
1928	21 Lyn	4.5	......	......	......	......	......	A1s	0.7	.017
1968	−22°1897	4.8	......	......	......	......	......	A8s	2.0	.028
1974	δ^1 C Mi	5.3	......	......	......	......	......	A5n	2.3	.025
2051	4 Car	5.1	......	......	A7n	2.6	.031	A5n	2.0	.024
2078	ϕ Gem	5.0	......	......	A0n	1.1	.016	A1n	1.1	.017
2088	+79°265	5.3	......	......	......	......	......	A0s	0.7	.012
2091	85 Gem	5.4	......	......	......	......	......	A1s	1.0	.013
2120	−18°2118	4.6	......	......	......	......	......	A0n	0.7	.017
2138	8 Cnc	5.1	......	......	......	......	......	A0n	0.6	.013
2185	29 Lyn	5.5	......	......	A3n	2.0	.019	A3n	1.9	.019
2237	30 Mon	4.0	−0.6	.012T	A0n	0.9	0.024	A0n	0.1	.017
2264	2 U Ma	5.4	......	......	......	......	......	A6s	2.2	.023
2327	γ Cnc	4.7	−0.3	0.010T	......	......	......	A1n	0.4	0.014

TABLE I—*Continued*

Boss	Name	H.D. m	Trig. or Gr. M	Trig. or Gr. p	Mt. Wilson Class	Mt. Wilson M	Mt. Wilson p	Douglas Class	Douglas M	Douglas p
2339	49 Cnc	5.6	......	......	......	......	......	A5s	1.2	0″.013
2398	59 Cnc	5.5	......	......	......	......	......	A2n	2.0	.020
2404	ι U Ma	3.1	2.9	0″.090T	A4n	2.2	0″.066	A4n	1.9	.058
2407	α Cnc	4.3	......	......	A4s	1.7	.030	A4s	1.8	.032
2479	θ Hyd	3.8	−0.1	.017T	A1n	1.3	.032	A0n	......	......
2495	38 Lyn	4.0	1.8	.037T	B9n	0.6	.021	A0n	1.9	.038
2559	τ^2 Hyd	4.5	......	......	......	......	......	A3n	1.9	.030
2584	42 Lyn	5.2	......	......	A5n	2.4	.026	A5n	2.1	.024
2637	φ U Ma	4.5	......	......	A1s	0.9	.015	A2s	1.2	.022
2642	22 Leo	5.3	3.2	.039T	A5n	2.2	.024	A4n	2.3	.025
2655	31 U Ma	5.3	......	......	......	......	......	A1n	0.0	.009
2692	21 L Mi	4.5	......	......	A2n	1.8	.028	A2n	1.3	.023
2697	15 Sex	4.5	......	......	......	......	......	A0s	0.0	.013
2729	λ U Ma	3.5	......	......	......	......	......	A4s	1.2	.035
2735	ε Sex	5.4	......	......	......	......	......	A7s	2.6	.028
2754	30 U Ma	4.9	......	......	......	......	......	A3s	1.1	.017
2900	ω U Ma	4.8	......	......	......	......	......	A0s	0.0	.011
2930	β U Ma	2.4	0.8	.046G	A3s	1.0	.054	A3s	0.3	.038
2932	60 Leo	4.4	0.1	.014T	......	......	......	A4s	0.2	.014
2972	δ Leo	2.6	2.2	.085G	A2n	1.7	.066	A1n	1.0	.048
2974	θ Leo	3.4	0.0	.021T	A2s	0.9	.032	A3s	0.2	.023
2987	55 U Ma	4.8	......	......	A0n	0.7	.016	A1s	0.2	.012
2990	σ Leo	4.1	......	......	B9s	−0.2	.014	B9s	0.0	.015
3023	57 U Ma	5.3	......	......	B9n	0.8	.012	B9n	0.4	.010
3063	59 U Ma	5.5	......	......	A4n	2.0	.020	A6n	1.9	.019
3088	ξ Vir	5.1	......	......	A1n	1.5	.019	A1n	1.2	.017
3097	4 Vir	5.2	......	......	A1n	0.8	.015	A1s	0.6	.012
3101	β Leo	2.2	2.5	.114T	A2n	1.7	.079	A5s	2.4	.110
3117	γ U Ma	2.5	0.6	.041G	A0n	0.9	.048	A0n	0.7	.044
3126	η Crt	5.2	......	......	......	......	......	A0s	0.7	.013
3139	π Vir	4.6	......	......	......	......	......	A3n	1.4	.023
3182	+78°412	5.1	......	......	......	......	......	F0n	2.9	.036
3190	δ U Ma	3.4	1.7	.045G	A0n	0.9	.032	A0n	......	......
3210	η Vir	4.0	......	......	......	......	......	A2s	1.2	.028
3240	14 Com	5.2	......	......	......	......	......	A6n	3.0	.036
3244	16 Com	5.0	......	......	......	......	......	A4s	2.6	.033
3266	21 Com	5.4	......	......	A3s	1.0	.014	A3s	1.0	.013
3277	21 Vir	5.4	......	......	B9n	0.6	.010	B9n	0.2	.009
3283	23 Com	4.8	......	......	......	......	......	A0s	0.3	.013
3309	ρ Vir	5.0	......	......	B9n	0.6	.014	B9n	0.4	.012
3310	31 Vir	5.5	......	......	B9n	0.6	.010	A0n	0.7	.011
3323	32 Vir	5.2	......	......	A6n	2.4	.027	A7s	2.4	.028
3354	+84°289	5.8	......	......	......	......	......	A0s	0.4	.008
3356	+84°290	5.3	......	......	......	......	......	A0n	0.2	.009
3370	α^1 C Vn	5.4	......	......	......	......	......	A8s	3.3	.028
3371	α^2 C Vn	2.9	1.1	.044T	A1s	0.6	.034	A1s	1.1	.044
3409	θ Vir	4.4	−0.4	.011T	A2s	0.9	.020	A2s	−0.3	.011
3450	21 C Vn	5.1	......	......	......	......	......	B9n	0.3	.011
3474	ζ U Ma	2.4	0.6	.044G	A2s	1.1	.054	A2s	0.6	.044
3475	ζ^2 U Ma	4.0	2.3	.046G	A8s	2.0	.052	A5s	1.8	.036
3480	80 U Ma	4.0	2.1	.042G	A1n	1.1	.026	A1n	2.2	.044
3506	o Vir	4.9	0.6	0.014G	A3s	1.5	0.021	A5s	0.7	0.014

TABLE I—*Continued*

Boss	Name	H.D. m	Trig. or Gr. M	Trig. or Gr. p	Mt. Wilson Class	Mt. Wilson M	Mt. Wilson p	Douglas Class	Douglas M	Douglas p
3508	ζ Vir	3.4	......	......	......	......	......	A0n	0.9	0″.032
3509	81 U Ma	5.5	......	......	......	......	......	A0n	0.8	.011
3512	24 C Vn	4.6	......	......	......	......	......	A0n	0.7	.017
3518	25 C Vn	4.9	3.5	0″.052T	A1n	1.5	0″.021	A1n	1.8	.024
3526	+11°2589	5.5	1.4	.015T	A7n	2.5	.018	A7n	2.5	.025
3530	82 U Ma	5.3	......	......	......	......	......	A1n	1.0	.014
3561	84 U Ma	5.5	......	......	......	......	......	A1s	0.6	.010
3612	τ Vir	4.3	......	......	A1n	1.1	.023	A0n	1.4	.026
3654	κ Boo	4.6	1.6	.025T	A4n	2.2	.034	A5n	1.8	.028
3666	λ Boo	4.3	2.4	.041T	A1n	1.1	.023	A0n	1.3	.025
3692	+9°2882	5.1	1.2	.017T	B9n	0.8	.014	B9n	0.9	.014
3722	γ Boo	3.0	......	......	A3n	2.0	.062	A5n	2.3	.072
3749	π Boo Br	4.9	......	......	......	......	......	A2s	−0.3	.009
3752	ζ Boo	4.4	0.4	.016G	A0n	0.9	.020	A0n	0.5	.017
3787	α^2 Lib	2.9	......	......	F1n	2.9	.100	A6n	2.2	.072
3911	+52°1869	5.5	......	......	A2n	1.5	.016	A2n	1.8	.018
3928	γ U Mi	3.1	......	......	......	......	......	A2s	1.5	.048
3939	10 Ser	5.1	......	......	......	......	......	A6s	2.5	.030
3960	δ Ser Br	4.2	−0.2	.013T	A4n	2.4	.044	A7n	2.7	.050
3961	α Cr B	2.3	0.3	.041G	A0n	0.9	.052	A1n	0.8	.050
3998	γ Cr B	3.9	0.5	.021T	A0n	1.1	.026	A0n	0.8	.024
4004	+52°1898	5.5	......	......	......	......	......	A1s	0.5	.010
4009	β Ser	3.7	0.6	.023G	A1n	1.1	.030	A0n	0.0	.018
4016	μ Ser	3.6	......	......	A0s	0.4	.022	A0s	1.0	.030
4022	β 946	5.8	......	......	A6s	2.3	.020	A8s	1.9	.017
4026	ε Ser	3.8	1.5	.035T	A6s	1.8	.042	A4s	1.7	.038
4028	36 Ser	5.2	......	......	A0n	0.9	.014	A0n	1.1	.015
4072	+55°1793	5.0	......	......	A5n	2.5	.032	A4n	1.8	.023
4081	π Ser	4.8	......	......	......	......	......	A3n	1.5	.022
4229	16 Dra	5.6	......	......	B9s	0.4	.009	B9s	0.4	.009
4232	17 Dra	5.6	......	......	......	......	......	B9n	0.2	.008
4376	δ Her	3.2	0.4	.028T	A0n	0.9	.035	A0n	1.0	.036
4581	72 Oph	3.7	1.5	.037T	A5s	1.8	.042	A5s	2.1	.048
4747	ϵ^1 Lyr	5.1	......	......	......	......	......	A1n	1.1	.016
4749	ϵ^2 Lyr	5.1	......	......	......	......	......	A1n	1.3	.017
4752	ζ^1 Lyr	4.3	1.4	.026T	A5s	2.2	.037	A4s	1.5	.028
4754	ζ^2 Lyr	5.9	3.3	.030T	A1n	1.5	.013	A1n	1.9	.016
4761	111 Her	4.4	3.1	.056T	A2n	2.0	.034	A4n	2.6	.044
4802	θ^1 Ser	4.5	......	......	......	......	......	A1n	1.3	.023
4803	θ^2 Ser	5.4	......	......	......	......	......	A1n	1.8	.019
4824	γ Lyr	3.3	−1.3	.012T	B9s	−0.2	.020	B9n	−0.2	.020
4858	ζ Aql	3.0	0.8	.037T	B9n	0.8	.036	B9n	......	......
4988	ι Cyg	3.9	0.2	.018T	A1n	1.1	.028	A1n	1.0	.026
5048	δ Cyg	3.0	1.7	.055T	A1n	1.1	.042	B9n	......	......
5062	α Aql	0.9	2.5	.203T	A2n	1.7	.145	A1n	2.0	.166
5186	o^1 Cyg	5.0	......	......	......	......	......	A1n	1.6	.021
5187	o^2 Cyg	4.0	......	......	......	......	......	B9s	0.6	.021
5337	ε Aqr	3.8	0.6	.023T	A1n	1.6	.037	A1s	1.0	.028
5480	α Cep	2.6	2.2	.084T	A2n	1.3	.056	A2n	2.5	.096
5600	δ Cap	3.0	3.3	.115T	A3n	2.2	.068	A6s	2.2	.069
6031	κ Psc	4.9	3.1	0.043T	A3s	1.2	0.018	A3s	0.7	0.014

Draper classification but a personal classification following very closely that of Mount Wilson investigators. Hence it is satisfactory to find that the writer's average magnitudes both for *n* and *s* stars of each subclass show a very close agreement with the means adopted by Mount Wilson and by Arcetri.

A crucial test of the individual accuracy of certain magnitudes is that suggested by Shajn,[1] based upon the fact that the components of a binary system have the same parallax and should therefore have the same difference in their absolute magnitudes as in their apparent magnitudes. In other words, for each pair the following relation should hold:

$$\Delta M - \Delta m = 0 .$$

For twelve such pairs the values of absolute magnitude determined by means of the writer's criteria gave an average of

$$\Delta M - \Delta m = \pm 0.34 .$$

As this is within the probable error of individual values of M, the conclusion is that this test gives evidence in favor of the accuracy of this method of determining spectroscopic magnitudes.

One pair calls for special mention—Boss 4752, 4754 (ζ^1 and ζ^2 Lyrae). The trigonometric values of absolute magnitude are in good accord, but the spectroscopic magnitudes as determined at Mount Wilson lead to

$$\Delta M - \Delta m = -2.3 ,$$

while the writer's values lead also to a large discrepancy, -1.2. The type of the fainter component (A1*n*) is certainly earlier than that of the primary (A4*s*),[2] and its magnitude must therefore be very much greater than the average magnitude (1.3) for stars of class A1*n*. This represents a case where the method of mean magnitude per spectral subclass fails utterly. The present criteria are not completely successful, but they improve matters to some extent and at least give ΔM and Δm the same sign.

[1] *Astrophysical Journal*, 62, 104, 1925.

[2] H.D. classification for ζ^1, ζ^2 Lyrae, A3, A3; Mount Wilson classification, A5*s*, A1*n*.

The natural expectation that any set of absolute magnitudes would show a correlation with the corresponding proper motions was confirmed by Mount Wilson investigators with regard to their spectroscopic magnitudes and by Dr. Struve with respect to the writer's magnitudes. But an attempt to find an analogous relation using reduced proper motion indicates that no such relation exists, the correlation coefficient evaluated rigorously for H and M in respect to one hundred and twenty-nine stars being 0.030. The applicability of the H function in this case evidently requires further investigation.

OUTSTANDING PROBLEMS

That the spectra of A stars present a peculiar problem has been stressed by Dr. Shapley[1] and others.[2] This investigation is a confirmation of the belief that there is present in the atmospheres of stars, at this critical stage of evolution, some unknown or at least unrecognized factor which plays a part in determining the nature of the spectra. What is the true significance of the *s* or *n* character of the lines in different spectra? Why are intense strontium and silicon lines so frequently associated with a spectrum having sharp lines? What factors are just balancing or merging their effects when a spectrum is neither distinctly *s* nor *n* but of so intermediate a character that two investigators will differ as to the group to which it belongs, while a third investigator meets the difficulty by calling it *sn?*

Perhaps a thorough study of the variations in the widths of lines associated with other spectral characteristics may lead eventually to the understanding of some of these problems.

A paper containing a more complete discussion of the results obtained for the individual stars studied, and the curves used in establishing the criteria, is published in the *Journal of the Royal Astronomical Society of Canada*, for October 1926, covering pages 265 to 302 of Volume 20 of that *Journal.*

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October 1926

[1] "Report of the Committee on Spectral Classification," *Transactions of the International Astronomical Union*, 2, 117, 1925.

[2] *Harvard Circular*, No. 264.