42. GIANTS AND DWARFS

By Ejnar Hertzsprung

In volume 28 of the "Annals of the Astronomical Observatory of Harvard College" a detailed survey of the spectra is given for northern and southern bright stars by Antonia C. Maury and Annie J. Cannon, respectively.

The first two columns of Table 1 give a short summary of the spectral class designation used by the two authors. In the last two columns are listed characteristic stars along with their spectral types. For a more detailed description of the characteristics used we must refer to the original papers cited above. Here we can find room for only a few words concerning the three sub-classifications *b, a,* and *c*. The *b* stars have broader lines than those of "division" *a*. The relative intensities of the lines seem, however, to be equal for *a*- and *b*-stars "so that there appears to be no decided difference in the constitution of the stars belonging, respectively, to these two divisions." As the most important characteristics of subclass *c* we can mention, first, that the lines are unusually narrow and sharp; second, that among the "metallic" lines others occur which are not identifiable with any solar lines, and the relative intensities of the remainder do not correspond with the intensities observed in the solar spectrum. "In general, division *c* is distinguished by the strongly defined character of its lines, and it seems that stars of this division must differ more decidedly in constitution from those of division *a* than is the case with those of division *b*." Antonia C. Maury suspects that the *a*- and *b*-stars on the one hand and the *c*-stars on the other, belong to collateral series of development. That is to say not all stars have the same spectral development. What determines such a differentiation (differences in mass and constitution, etc.) is a question that remains unanswered.

The question arises how great the systematic differences of the brightness, reduced to a common distance, of stars of the different groups will be. For this purpose I have used the proper motions of the stars in the following simple manner.

For each group a value was determined above and below which lies,

Table I

Spectral Class according to AJC I	Spectral Class according to ACM II	Number in ACM III	Number Adjusted IV	Mean annual proper motion for $m_H=0$ V	Mean magnitude reduced to the annual Proper Motion of ″01 VI	Mean magnitude reduced to the annual Proper Motion of ″01: Number VII	Mean magnitude reduced to the annual Proper Motion of ″01 VIII	Mean deviation from the mean IX	Mean deviation from the mean X	Mean error of the mean XI	Number XII	Star Color: m_D for $m_H=4.5$ XIII	Star Color: $\frac{\Delta m_H}{\Delta m_D}$ XIV	Characteristic Star: Name XV	Characteristic Star: Spectrum XVI
Oe5B	I	7	3	″067	(4.13)						4	(4.66)		*S* Monocerotis	*Ib*
B to B3A	II	14	11	.059	3.84						9	4.73	1.36	ε Orionis	II*a*
	III	17	11	.069	4.20	38	4.37	−3.02	+2.08	±.41	13	4.65	1.35	α Virginis	III*b*
	IV	30	9	.069	4.19						26	4.58	1.35	γ Orionis	IV*a*
	IV′	20	7	.127	5.51						18	4.59	1.17	π_4 Orionis	IV′*a*
B5A to B9A	V	22	9	.199	6.49						19	4.55	1.32	τ Orionis	V*b*
	VI	22	10	.411	8.07	21	7.25	−1.40	+1.22	±.29	19	4.58	1.30	α Leonis	VI*b*
	VI′	3	2	.520	(8.58)						3	(4.49)		η Aquarii	VI′*b*
A	VII	32	21	.386	7.93	47	8.05	−1.38	+1.48	±.21	38	4.56	1.27	α Canis maj.	VII*a*
	VIII	43	26	.439	8.21						43	4.65	1.34	α Geminorum	VIII*a*
AF and F	IX	29	16	.547	8.69						26	4.73	1.22	δ Ursae maj.	IX*b*
	X	19	9	.646	9.05	34	9.06	−2.03	+1.77	±.33	15	4.82	1.36	α Aquilae	X*b*
	XI	13	7	.721	9.29						13	4.86	1.21	δ Aquilae	XI*a,b*
	XI′	3	2	.568	(8.77)						3	(4.80)		ζ Leonis	XI′*ab*
FG	XII	30	18	1.197	10.39	30	11.23	−2.25	+2.06	±.40	24	5.03	1.36	α Canis min.	XII*a*
	XIII	21	12	3.251	12.56						21	5.02	1.41	χ_1 Orionis	XIII*a*
G and GK	XIII′	1	1	2.466	(11.96)						1	(5.16)		θ Persei	XIII′*a*
	XIV	19	11	.481	8.41	24	7.93	−2.46	+4.01	±.31	16	5.23	1.34	α Aurigae, Sun	XIV*a*
	XIV′	21	12	.321	7.53						20	5.29	1.53	κ Geminorum	XIV′*a*
K	XV_1	25	21	1.081	10.17						24	5.39	1.46	α Bootis	XV_1a
	XV	49	21	.745	9.36	74	9.38	−2.06	+1.68	±.22	42	5.44	1.49		
	XV_2	38	32	.658	9.09						36	5.46	1.58	α Cassiopeiae	XV_2a
KM	XV′	6	5	.908	4.79	21	7.77	−3.07	+2.01	±.56	6	(5.75)		β Cancri	XV′*a*
	XVI	23	16	.449	8.26						22	5.68	1.75	α Tauri	XVI*a*
Ma	XVII	18	9	.378	7.89	15	8.28	−1.12	+1.15	±.30	15	5.81	1.41	β Andromedae	XVII*a*
	XVIII	20	6	.479	8.40						16	5.84	1.45	α Orionis	XVIII*a*
	XIX	6	1	.891	(9.75)						5	5.81		ρ Persei	XIX*a*

respectively, one-half of the proper motions expressed in arc of a great circle, and reduced to magnitude 0. These values are listed in column V of Table 1. In column VI are found the corresponding magnitudes reduced to a proper motion of 1″ in a hundred years. (Reduced to 1″ annual proper motion the stars would be 10 magnitudes brighter.) In column VIII are the mean reduced stellar magnitudes for somewhat large groups, and in the following two columns the values above and below which 15% of the total lies. These values will be, therefore, the mean deviation from the median. Finally there are listed in column XI the mean errors of the medians.

Table 1 contains only stars of subclasses *a* and *b* for which I have found proper motions based on the latest determinations of the Fundamental stars (Newcomb precession constants). Also in addition to the *c*-stars, all stars are omitted which are recognized as variable or the spectra of which were described as "peculiar." The total number of the *a* and *b* stars found in Antonia C. Maury's catalogue are given in column III, and in column IV the number of stars remaining after these omissions. I have also attempted to bring together all stars brighter than the 5th magnitude for which spectral class (according to the above-named authors, or to the Draper Catalogue) as well as proper motion could be found, and I come to the same result as that which appears in Table 1. In spite of the small number (308) of stars taken into consideration in Table 1, I consider the picture they give us as more reliable than would be that from a larger number of much more uncertainly classified spectra used in connection with a too great value for the small proper motions (Orion stars).

The radial velocity found for about 60 stars has an approximately typical distribution with a mean deviation from zero of some ±20 km/sec. It is therefore probable that the projection of the absolute proper motions on a randomly chosen direction would also have a typical distribution. We have, however, also considered the projection of the apparent proper motions on a plane at right angles to the line of sight; and we ask which mean deviation in the star magnitudes, reduced to equal apparent proper motions, would uniquely result (corresponding to the assumption that all stars have the same absolute magnitude). The values are about +1.2 and −1.57 magnitudes. Comparing these with those in columns IX and X in Table 1, we find that the stars which were put together in the A-class cannot differ very much among themselves in absolute magnitude. According to this result, combined with the fact that membership in spectral A-class is easily recognized, I have assembled for 100 A-stars of magnitude 4.62–5.00 the proper motions in declination only. If one arranges these according to magnitude, the value $-.''008$ lies in the middle, and respectively 15% of the total is over $+.''0325$ and under $-.''0575$. From this can be calculated the mean deviation $\pm.''0448$ annually, which would correspond to a speed of ± 20 km/sec, or 4 astronomical units per year. According to this, we find for the 100 A-stars of mean magnitude 4.84 the mean parallax of $.''0112$. In Table 1 the magnitudes are reduced to a mean annual proper motion of $.''01$ in arc of a great circle, corresponding to a parallax of some $.''002$. For the 100 A-stars we compute with the parallax the mean stellar magnitude of 8.6, in fair agreement with the value 8.05 from Table 1. . . .

Further I have in column XIII, Table 1, inserted values which can be taken as a sort of color-equivalent and which were derived in the following way from the visual magnitudes taken from the revised Harvard Photometry (H.P.) and the photographic magnitudes (corresponding to G-line light of wave length $.432\mu$) taken from the Draper Catalogue (D.C.). Within each group, for the number of stars in column XII, both magnitudes m_H and m_D were brought together, and, on the approximately correct assumption that a linear relation exists between them, that value of m_D was calculated which corresponds to $M_H = 4.5$. Further we have in column XIV for each group the computed ratios $\Delta m_H : \Delta m_D$. Actually they should be constant with the value 1. That they increase from white through yellow to red may be due to the Purkinje phenomenon. That they all lie appreciably above 1 can be due to the circumstance that the normal intensity scale, which was used for the determination of the D.C. magnitudes through comparison of the spectral darkening in the neighborhood of the G-line ($\lambda = .432\mu$), was established not in pure G-light but by means of the Carcel-lampe. . . .

The minimum shown in column XIII in the neighborhood of the A-group appears to be real. Accordingly the Orion stars would be somewhat yellower than the A-stars. . . .

In any case we may say that the annual proper motion of an average *c*-star, reduced to magnitude 0, amounts to only a few hundredths of a second. With the relatively large errors of these small values, a dependence on spectral class cannot be recognized. In other words, the *c*-stars are at least as bright as the Orion stars. In both of the spectroscopic binaries *o* Andromedae and β Lyrae the brightness of the *c*-star and of the companion star of the Orion type appear to be of the same order of brightness. The proper motions (not here given) are all small, according to the Auwers-Bradley Catalogue. . . . For the stars in Annie J. Cannon's listing that have narrow sharp lines, I can also find only small proper motions. This result confirms the assumption of Antonia C. Maury that the *c*-stars are something unique.

When the *c*- and *ac*-stars are looked at in summary fashion one sees that with increasing Class number [advancing toward redder spectra] the *c*-characteristic diminishes, and that these stars stop exactly where the bright K-stars begin.