29. COMMISSION DES SPECTRES STELLAIRES

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The writing of the Draft Report of Commission 29 brings to light once again the need of better defining the province of its domain since there is an overlap with areas of other commissions such as 27, 30 and 42, which use stellar spectra for the investigations they are concerned with. In what follows I have tried as far as possible not to include whatever would naturally go into the Draft Reports of other commissions and whatever Dr Feast has already included in his report on the spectra of variable stars for Commission 27. As a result, the report on some items is only fragmentary.

In my task, I have had the help of the Vice-President and of the members of the Organizing Committee who have prepared reports of the work done in the southern hemisphere, Europe (except U.S.S.R.), U.S.S.R., Japan and Canada, respectively. Dr Oke contributed a report on abundances which I have incorporated within the information under this heading. Mme Herman prepared a report of her working group on Be stars from which I have extracted whatever was relevant to our Commission. I am very grateful to all of them for their help. I am also grateful to Drs Oke and Cayrel de Strobel for the reports concerning the Committees they head. They are appended at the end of this report.

The report and the bibliographical references reflect the enormous amount of work in the field of stellar spectra done in the last three years. Commission 29 is very large indeed but it is also most active.

Although there must certainly be better ways of doing it, the report has been divided in two main sections, namely, general spectroscopic studies and abundance determinations. Of course, in trying to fit the report information into the two sections some material that should have perhaps been included in the second one was considered better fitted for the first section.

Last but not least, I would like to express my gratitude to the Vice-President and to the members of the Organizing Committee for their contribution to the bibliography.

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I. GENERAL SPECTROSCOPIC STUDIES

(a) *Early-Type Stars*

Miss Underhill (1966*a*) has taken the task of putting together and discussing the observational results of early-type stars and has suggested (Underhill 1965) that the persistence of the Mg II 4481 doublet in O-type stars is due to the fact that the very high ionization potential for Mg III forces most Mg atoms to stay in the first stage of ionization, even at the high temperatures of the O stars.

Underhill and de Groot (1964) have published identification and equivalent widths of the spectral lines of 10 Lacertae in the range λλ 3074–5160 Å; it was possible to identify only about 80% of a total of 2000 lines, and Ne and O were found. An interesting fact found by van Helden (1966) is that in 10 Lacertae the profiles and intensities of O II and Fe III vary in time intervals smaller than ten minutes, while the radial velocities display irregular short period variations, according to Grygar's (1964) measures.

Y. Andrillat and L. Houziaux (1966*a*) have studied 80 B and Be stars in the near infrared, compare, in 20 of them, the homologous lines of the Balmer and Paschen series and determine the intensity variation of the O I triplet at 7772 Å in relation with spectral type and luminosity class (1966*b*).

No differences in the atmospheric parameters for the high latitude O-type stars HD 93 521 and HD 60 848 and for O stars in the galactic plane has been found by Kumaigorodskaya (1967).

P. Smeyers (1966) is interested in determining the profiles of the Mg II λλ 7877 and 7896 Å in a B9 V star in order to compare them with the profiles computed from a model atmosphere.

In regard to the B stars, the late R. M. Petrie (1965*a*) had almost completed his studies of B stars of magnitudes 7 to 9 visible at Victoria and a paper by Petrie and Lee (1966) gives H γ measures and luminosities for 571 B stars. A revised luminosity-H γ calibration that agrees well with other luminosity studies was also published by Petrie (1965*b*).

From material on OB stars secured at Pretoria and in Cambridge, Andrews (1965) has found that for class V stars, H α is about as good an absolute magnitude index as H β or H γ while for supergiants it is more accurate.

Aller and Jugaku (1967) have completed a description of their work on the B stars which has resulted in line intensities and line profiles for λ Orionis, 10 Lacertae, φ Orionis, ξ_1 Canis Majoris, 15 Canis Majoris, HD 36 959, HD 36 960, 22 Orionis and 114 Tauri.

Inspecting the early-type spectra at Victoria, Bidelman has discovered several B-type stars showing variable helium lines. This interesting phenomenon had previously been reported for HR 5378 (Bidelman, 1965) and for the first time in 1957 by Struve, Sahade, Lynds and Huang in Maia (20c Tauri).

At Mt Wilson, Heintze is studying H-line profiles in the sharp line B stars, τ Herculis, ι Herculis, ι Arietis and ζ Draconis to compare them with theoretical line profiles.

(b) *'Blue Stragglers'*

Deutsch is studying the so-called 'blue stragglers' in M 67 and NGC 752; the spectra obtained confirm and extend Wallerstein and Herbig's results that in most of these stars the spectrum lines are appreciable broadened by stellar rotation.

Since the 'blue stragglers' appear to be metamorphs of the late F dwarfs, Deutsch proposes that on the main sequence the solar-type stars suffer a rotational deceleration largely confined to the hydrogen convective zone leaving the radiative core with its angular momentum only slightly diminished even after times of the order of 10^{10} years.

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(c) *Of and Wolf-Rayet Stars*

Kumaigorodskaya (1964) has investigated the dependences of emission-line intensities with temperature and luminosity for 13 Of stars and has found that these stars can be grouped in two sequences similar as those of the Wolf-Rayet stars. Nitrogen Of stars appear to be hotter than the carbon Of stars.

G. A. Gurzadian and H. S. Tchaurushian (1964) have determined emission line intensities, velocities of expansion of the envelopes and spectrophotometric gradients of the Wolf-Rayet stars HD 165 688, 211 564, 213 049 and R 114, while the energy distribution of the continuous spectrum of V 444 Cygni has been studied by Ivanova *et al.* (1965) at different phases; a decrease of the spectrophotometric temperature at the two minima was found.

Vainu Bappu and Ganesh are concentrating their efforts in the investigation of the Wolf-Rayet stars and are preparing an atlas of tracings of Wolf-Rayet spectra, which will include a wide range of dispersions, from 10 Å/mm to 250 Å/mm. Infrared spectra of HD 192 103 (WC7), HD 162 763 (WC6), HD 68 273 (WC7), HD 192 163 (WN6), HD 50 896 (WN5), HD 93 131 (WN7), HD 92 740 (WN7) and HD 151 932 (WN 7·5) have been taken and line identifications have been completed; this work will be published in the *Kodaikanal Obs. Bull.*

The two Indian astronomers have also determined excitation temperatures of four WC stars and found values which range from 24 000° to 57 000°. On the other hand D. M. Pyper (1966) from their *UBV* colour indices corrected for emission, finds a difference of about 20 000° between the WN and the WC stars, the WN stars being hotter.

At Mt Wilson, Kuhi has studied energy distribution of Wolf-Rayet stars in the range λ 3200 to λ 11 000 with the Cassegrain photo-electric scanner used as a narrow-band photometer and concluded that they are definitely peculiar and different from those of blackbodies; therefore, no unique temperature can be defined. The apparent different sequences upon which the WC and WNs appear to fall can be explained by emission-line contamination. Kuhi's observations confirmed the behaviour in Wolf-Rayet binaries of He II emission phase-wise found previously by Hiltner and also confirmed Sahade's earlier conclusion that ionization decreases outwards in the WR atmospheres; the most highly ionized atoms appear to occur in a geometrically small region and the emitting volume for the lines of lower ionization appear to be very large. Also there seems to be some kind of a reflection effect due to the O star. Moreover, Kuhi (1966) has studied the infrared spectrum, from 8000 to 10 900 Å, of some bright Wolf-Rayet stars.

R. Barbon *et al.* (1965) suggest a strong activity in the envelope of the WR stars while Bertola finds that in HD 50 896 the velocities and the profiles of He I 4100 and N IV 4058 are variables although the radial velocity variations do not suggest binary motion.

Code and Bless (1964) described the infrared spectra, (from 8600 to 10 830 Å) of γ_2 Velorum and developed a model for the WR envelope in which collisional processes by particles ejected into a thermalized envelope play an important role in the ionization equilibrium of the envelope.

A. Underhill (1966*b*) has examined the position of the WR stars in the HR diagram and concluded that it is reasonable to consider them as contracting objects that are still approaching the main sequence, in agreement with a suggestion made for the first time in 1958 by Sahade. In this connection it is interesting to note a discussion by Sahade (1965) who pointed out that the presently accepted value for the density of the WR component of V444 Cygni is not reliable.

Stepien (1964) has discussed the spectroscopic and photometric data in regard to the WR component of V444 Cygni. New WR stars have been reported by The (1964*a*, *b*).

(*d*) *Intermediate and Late-Type Stars*

It is interesting to note that Peat (1964) has been able to establish a way of distinguishing giants from supergiants among the F, G and K stars by plotting the intensity of the Ca II triplet in the red-orange against the intensity of the b-line of Mg II. The same procedure permits the detection of subdwarfs in the case of high-velocity G and K stars.

At the 1965 NASA Symposium, Wright (1965) discussed the low excitation temperatures obtained for A- and F-type stars using the Fe I *f*-values, and at the Trieste Colloquium presented a review paper on the spectra of late-type stars (Wright, 1966).

Clarke and Grainger (1965) have detected differential polarization effects on the profiles of the H β line of γ Ursae Majoris, and at Kodaikanal, Bhatnagar has started a programme of observation of the infrared O I lines in A and F stars at 250 Å/mm.

In regard to the late-type stars, concentrated efforts are being made in Tokyo and in Pasadena. Some of the results obtained in Tokyo by Fujita and his collaborators during the past few years have been recently published (Fujita 1966) and special emphasis is being given now to an identification programme that will proceed towards wavelengths shorter than those covered previously in similar work.

Yamashita has studied the late-type spectra available at Victoria and found several new CH stars. In South Africa, Feast is studying coudé spectra of southern S-type stars.

(*e*) *T Tauri Stars*

Herbig has accumulated a considerable amount of information on the infrared Ca II triplet which are characteristically very strong in T Tauri stars, even though they are very weak in dMe stars that have comparable H and K emission intensities; the effect is probably due to heavy self-absorption in T Tauri stars.

Herbig (1966) has interpreted FU Orionis as a star which has very recently appeared at the top of the vertical branch of its evolutionary track, an interpretation which implies that the high Li abundances observed in T Tauri stars must have its origin either in the origina interstellar material or been produced before the star became luminous in the usual sense.

Kuhi has obtained photoelectric spectrum scans of several T Tauri stars from λ 3200 to λ 11 000 and found that many of these stars are excessively red suggesting that the reddening may be of circumstellar origin. The origin of the peculiar excess ultraviolet emission in T Tauri stars is being investigated.

(*f*) *Giant and Supergiant Stars*

Zeinalov and Kopylov (1966) have identified about 600 spectral lines in the spectrum of the A0 Ib star η Leonis and carried out a detailed study of the velocity field in its atmosphere. The microturbulent velocity decreases with optical depth while the macroturbulent velocity goes in the opposite sense.

Variations of the equivalent widths and profiles of Hγ and Hδ and of the equivalent widths of metallic lines in η Leonis were found by Malov and Vitrichenko (1964), who were led to temperature variations of 1000°K, electron pressure variations up to a factor of 2 and radius variations up to about 30%.

Kupo and Mamatkazina (1966) have studied the continuum of HD 21 389, an A0 Ia star.

In a number of K and early M giants of luminosity class III Deutsch has found time variations in the profiles of the central components of Ca II 3933 similar to the ones reported previously by him in many K-type supergiants; the doubly-reversed features, at high spectral resolution, exhibit a surprising degree of fine structure suggesting variable chromospheric

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activity and sometimes the motion of a plage across the visible hemisphere, as the result of stellar rotation. The observations will be continued in a representative group of giants near K5 III.

Deutsch and Keenan are continuing obtaining spectrograms in the blue and violet (20 Å/mm) that show systematic intensity anomalies in various atomic absorption lines and also in the bands of AlO.

Griffin has prepared – publication is pending – a spectrophotometric atlas of Arcturus covering the wavelength region between 3600 and 8800 Å, and at least comparable in all respects with the Utrecht solar atlas. A catalogue of lines (about 7000) with wavelengths, equivalent widths, central intensities and identifications for $\lambda > 5000$ Å is well advanced. The work of cataloguing and indexing features was undertaken in collaboration with the present Mrs R. E. M. Griffin-Gasson, who has also investigated the atmospheric characteristics of Arcturus. The discovery by Griffin of the H and K emission reversals being variable in time, has been followed up by W. Liller observing H and K emissions in a number of stars with Griffin's photoelectric spectrophotometer. The Atlas of Arcturus has led to the discovery of [O I] and [Fe II] lines in Arcturus (Gasson and Pagel, 1966).

Griffin (1964*a*) found broad features at $\lambda\lambda$ 6318, 6344 and 6362 Å in Arcturus and in eleven other F5 to M0 stars which have been identified as calcium lines broadened by auto-ionization by Mitchell and Mohler who discovered them independently in the solar spectrum. The line at λ 6362 has been studied by Griffin and Liller with the photoelectric spectrometer just mentioned. Griffin (1964*b*) has also given line identifications of Arcturus in the 8875 to 11 200 Å region.

F. K. Edmonds, Jr. will measure line blanketing in the 1–2·5 μ region, using high-resolution Fourier transform spectroscopic observations obtained by P. Connes of the C.N.R.S. Bellevue Laboratories, in France, and in the $\lambda\lambda$ 3500–8800 Å region, using high-dispersion observations and equivalent width measurements of Griffin and Mrs Griffin-Gasson.

Kubiak (1966) has discussed the influence of TiO bands on magnitudes and colours of M-type giants, by using high-dispersion spectrograms obtained by Preston.

A detailed study of the spectrum of Procyon that comprises equivalent widths of 152 lines in the wavelength range $\lambda\lambda$ 3260–6610 Å and line profiles of Hα, Hβ and Ca II-K, and the measurement of the continuous spectrum and of line blanketing has been published by F. N. Edmonds, Jr. in two papers, the second one in collaboration with F. D. Talbert (Edmonds, 1965; Talbert and Edmonds, 1966).

Edmonds is also working on the photoelectric calibration of photographic equivalent widths of Procyon and Arcturus using the high-dispersion photoelectric scanner attached to the coudé spectrograph at the MacDonald Observatory.

F. Praderie is computing H lines in the atmospheres of AF-type stars.

Sargent (1965*a*) suspects the presence of [N II] at 6583–6548 Å in the spectrum of the G0 Ia star, HR 8752, which would imply the existence of a highly ionized region around the star; the star displays Hα and Hβ emission suggesting superficial mass loss.

Bonsack and Culver have continued their programme to determine, on high dispersion Mt Wilson spectra, wavelengths, equivalent widths and identification of the lines in the spectrum of the normal late G-type giant ϵ Virginis; the measurements and reductions are already complete for 6500 lines in the wavelength range 4000 to 9000 Å.

Smak (1966*a*) has determined a new bolometric corrections scale for M-type giants by using the spectrophotometric data of Stratoscope II and the available six-colour data; and combined his results with recent determinations by Mendoza and Johnson.

(g) *Be and Shell Stars*

A desire to co-ordinate and stimulate work on the Be stars led Mrs Herman to propose in 1961 at Berkeley the formation of a working group to which she is serving as chairman.

A somewhat condensed and free English version of her report follows:

'In spectroscopy or spectrophotometry certain groups are particularly active.

'At La Plata, C. Jaschek, with the collaboration of B. Kucewicz, has continued his search for H α emission in southern B0–A0 stars brighter than 6·5 magnitudes, and a list for the range B0–B5 has been published (Jaschek *et al.*, 1964), while Kucewicz (1965) has summarized the state of the search. C. and M. Jaschek have described several southern Be stars and, in particular, have reported that in 1965 HD 68 980 has displayed a sort of helium envelope with peculiar line profiles (C. and M. Jaschek, 1965; see also M. and C. Jaschek, 1964).

'Miss Underhill has secured a number of spectra of ζ Tauri at Victoria (October and December 1964) and at Kitt Peak (January 1966) and van der Wel, at Utrecht, has made a spectrophotometric study. In 1964 the shell absorption lines are shaded towards the violet while in 1966 the shading was towards the red.

'At David Dunlap, Heard has taken a series of spectrograms of φ Persei at 10 Å/mm.

'L. Houziaux and Mme Y. Andrillat have undertaken the study of the infrared region, specially at Haute-Provence. A report on the measurement of the Paschen lines and those of O_2 at 7771–5 and at 8446, with the aim of determining the envelope electronic temperature and the oxygen abundance, has been published (Andrillat and Houziaux, 1966*b*).

'At present, Houziaux is analysing the spectral variations of some 20 Be stars, between 7 and 8 magnitudes, observed in the last ten years.

'At Crimea, Boyarchuk and Pronik have studied the Hα profiles in HD 217 050, ζ Tauri, φ Persei, ψ Persei, 11 Camelopardalis and c Persei, finding that the wings are determined by radiation damping; they also reached the conclusion that the envelopes of the Be stars are oblated (Boyarchuk and Pronik, 1964). They find that the Be stars are somewhat reddened relative to the normal B stars, a phenomenon probably caused by the envelope; in the case of X Persei and χ Ophiuchi the Balmer decrement for the stars was found steeper than the Balmer decrement for the nebulae, apparently due to the large optical thickness of the Be envelopes for the Balmer lines radiation (Boyarchuk and Pronik, 1965*a*).

'In Italy, M. Hack and her collaborators (Hack *et al.*, 1964; Aydin *et al.*, 1965) have observed ζ Tauri from 1961 through 1964 and found that the envelope contracts and that the velocity of contraction has been decreasing.

'HD 50 138 has been observed at Haute-Provence by Mme Doazan, who found pulsations of the envelope; she has applied Sobolev's method to such an envelope (Doazan, 1965) and has also measured spectra of HD 218 393 taken between 1960 and 1964.

'Miss Lacoarret (1965) has studied the variations of the emission relative to the continuum in HD 168 957, HD 171 406, HD 171 780, HD 175 869, HD 177 648, HD 187 811, HD 191 610 and HD 174 237 and found periods of several years, while the V/R variations in HD 174 237 have a quasi periodicity of several days. She also discusses the characteristics of the envelopes and compares the results obtained by applying Miyamoto-Kogure, Pottasch and Sobolev's methods.

'Miss Delplace (1966) has been concerned also with ζ Tauri and discussed the variation of the Balmer decrement in relation with the variation in radial velocities of the Balmer series. The problem of the periods of the spectral variations is also concerning Peton, who is studying HD 45 910 and HD 4180, and Mme Herman who has observed emission, present again in 1964–65, in HD 142 926; this star appears to have also a small metallic envelope. Lecontel is

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investigating variations in β Canis Majoris stars in the hope of finding some relationship with the Be stars.

At La Plata, C. Jaschek is undertaking the continuation of the Merrill and Burwell's catalogue and bibliography of Be stars.'

Pik-Sin The (1964*c*, *d*; 1966*a*, *b*; The and Lim, 1964) has continued his search for Hα emission objects and it is rewarding to mention that Bidelman reports that the surveillance of the brighter Be stars carried on at Michigan for so many years by the late D. B. McLaughlin will be continued to some extent. Andrews and Breger (1966) have found that Achernar is a Be star, the brightest known.

At Helwan, R. Goubrous is studying the He I lines in some shell stars.

Mme Herman (1964) has confirmed the existence of double H absorptions in P Cygni, during certain periods and given a qualitative interpretation of the observed profiles in the framework of Sobolev's theory.

Y. Andrillat (1965*b*) has spectrographically observed a potassium eruption in the B9e star 4 Herculis, a phenomenon which is analogous to that observed by Barbier and Morguleff in two dwarfs stars HD 117 043 (dG6) and HD 88 230 (K7V) (Barbier and Morguleff, 1964). Y. Andrillat and N. Morguleff (1966*a*, *b*) have made a comparative study of the three stars known to display the phenomenon; they think that the phenomenon is not of atmospheric origin and plan to study its frequency by means of an objective grating and to continue investigating it in the case of the Sun.

At Abastumani, Alania (1964) has found in the spectrum of MWC 84 that since 1932 there has been an increase of the order of seven times in the ratio of the emission lines at λ 3889 and H β.

Dolidze *et al.* (1965) reports a decrease in the Balmer jump of HD 190073 in 1964–65 and Dolidze, Apriamashvili and Jimsheleishvili have measured the Balmer jump in V425 Cygni.

(*h*) *Ca II Emission*

In Pretoria, Warner has observed over 200 G, K and M stars south of declination $-20°$ for H and K emission; preliminary results show a good correlation between emission intensity and space velocity but there are indications that different stars in a given moving group do not necessarily have the same emission intensity even when they have identical spectral types.

Warner (1966*a*) has detected Ca II emission in Canopus, but this star does not obey the Wilson-Bappu relationship.

Wilson finds that as one proceeds down the main sequence slow rotations set in very abruptly at $B - V$ indices only 0·01 magnitude from the onset of Ca II emission (near F5 V) and that Ca II emission is characteristic of stars that develop chromospheres, chromospheric activity, and 'winds' and that such activity causes a loss of angular momentum with concomitant rotational braking. He is making now a strong effort to study stellar chromospheres by rapid and accurate measurements of the central emission components of H and K.

Wilson is also investigating the frequency distribution of the intensities of the chromospheric H and K emissions in main sequence K- and M-type stars. Since all the available evidence points to a close correlation between chromospheric activity and age for main sequence stars the frequency distribution should approximate the frequency distribution of stellar ages.

Thackeray (1964) has reported the presence of abnormally strong Ca II emission in a young K star that belongs to the Sco-Cen association, and Metrevely (1966) has announced that the K5 star, BD + 28° 637, displayed strong H and Ca II emissions on December 24 1960 while they appear to be absent at other nights.

(*i*) *Chromospheric He* I

Vaugham and Zirin discovered He I λ 10 830 in absorption in λ Andromedae and have looked for the same feature in late-type stars. About 86 stars (Go to M6) selected from Wilson-Bappu list have been observed and about half of them show He I λ 10 830 implying a hot chromosphere with temperatures exceeding 20 000°K. The strength of the line tends to increase with increasing Ca II H and K emission intensity, and it is violet displaced in virtually all supergiants as well as in some giants of luminosity class III. The He I λ 10 830 feature has been found in at least one F star, namely, α Canis Majoris.

(*j*) *Metallic-Line and Peculiar A Stars*

The field of metallic-line and peculiar A stars has been a most active and a considerable amount of information have been obtained. Review papers have been prepared by Sargent (1964), M. Hack (1965, 1966*a*) and a catalogue of peculiar A stars has been published by Bertaud (1965).

At La Plata, the Jascheks (M. and C. Jaschek, 1965) have analysed the information on the metallic-line and peculiar A stars and suggested that they represent a transient stage in a star's life; furthermore, on kinematical grounds they concluded that the metallic-line stars can not have gone through the giant stage. This conclusion finds support in the finding of an Ap star in I Persei by Kraft and in the presence of an Ap object in the o Velorum cluster.

A review paper on the magnetic stars has been produced by Ledoux and Renson (1966).

A preliminary determination of the magnetic field of α^2 Canis Venaticorum has been tried at the Okayama Astrophysical Observatory (Unno and Kato, 1965).

An important result is the discovery in β Coronae Borealis of the presence of a line due to lithium (Garstang, 1964) and of the possibility of variations in its intensity (Wallerstein and Hack, 1964). Hack and Faraggiana (1964) have discussed that discovery, and the results of the investigations of β Coronae Borealis and γ Equulei at Merate.

Adam (1965) has observed the magnetic variable HD 125 248 and found that the reduction in the amplitude of the magnetic field that was first noted by Babcock in 1953 is still continuing; the period, however, has remained remarkably constant over 17 years.

P. Renson (1965) has determined the variations in radial velocity, luminosity and magnetic field and found the variation in magnetic field in function of phase presents an assymetry and resembles the luminosity curve as is true for other magnetic variables.

Bruce Peterson (1966) has investigated the spectrum variables HD 124 224 and 56 Arietis and, from the equivalent widths of the variable lines of Si II and He I, has determined new epochs of maximum strength of the He I lines thus finding that the times of He I maxima coincide with those of minimum temperature determined from $(B - V)$ and from $H\gamma$ profiles as well as with the times of minimum light in V and minimum Si II. The intensity variations in Si II are very nearly in the same phase for lines that differ in excitation potential by 2·7 electron volts. These results conform better to a rigid rotator model than to a magnetic pulsation.

The Ap star HD 221 568 has been studied by Kodaira in the spectral range λλ 3800–7000 Å and Kondo (1965) has analysed the continuous spectrum of 63 Tauri finding that $T_{\text{eff}} \simeq 7600°$ = 7900° and log $g \simeq 4·0$. Also in Japan, Jugaku and Kikuchi are making a detailed spectrophotometric study of β Orionis on high dispersion Mt Wilson spectrograms that cover the range λλ 3100–8800 Å; the spectrum of this star has been investigated by Svolopoulos (1966*b*) on McDonald spectra from 3660 Å to $H\gamma$ line identifications and intensities are given and electron pressure and the amount of hydrogen above the photosphere have been determined.

Osawa (1965) finds that the Ap stars may have ultraviolet excesses that become more pronounced if the colour indices are corrected for line blanketing.

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A list of 3000 lines and their equivalent widths for γ Equulei in the range $\lambda\lambda$ 3730–6593 Å has been published by M. Hack and M. S. Matthews (1965) by using material with dispersions of 2·8 to 4·5 Å/mm; only 600 of these lines are unblended.

Bidelman is planning to publish soon line identifications of a number of Ap stars studied on 2 Å/mm coudé Lick plates, beginning with the manganese stars; the analysis of line intensities will be done as a second step.

Bidelman is also studying a number of interesting stars two of which deserve mention at this time, namely, HR 4487 (worked out in collaboration with J. Baumert) which appears to have very high abundance of yttrium and zirconium, and HD 3473, which appears to be the only example of a Si-Mg star.

Inspecting the spectra of most of the early-type stars investigated at the Dominion Astrophysical Observatory, Victoria, Bidelman has discovered a considerable number of new Ap and Am stars, and E. N. Walker (1966*b*) has recently published a list of 25 new Am stars.

Other interesting results were reported by Bidelman at the 1964 Utrecht Symposium on Abundances.

Svolopoulos (1966*a*) have analysed the spectrum of the manganese star α Andromedae, and given line identification and their intensities; electron pressure and the amount of hydrogen above the photosphere have been determined.

Wehlau (1965) has studied the spectrum of the Ap star χ Serpentis and also that of 73 Draconis (Wehlau 1966), where he found large variations in the K line; a spectrophotometric analysis of 73 Draconis is underway. John Rice is doing similar work on HD 174 650, where large variations in line intensities have been noted. 73 Draconis has been studied also by Galkin (1964) who has determined the variations with phase of the residual intensities of 19 lines, has constructed curves of growth and determined the main atmospheric parameters.

Renson (1966) finds that the magnetic variable HD 8441 is a spectroscopic binary with a period of 106·27 days and that the published period of $2^{d}.9632$ for the magnetic variation is due to chance.

Abt (1965) has measured 500 coudé spectra of 55 normal A4-F2 IV, V stars and found no binaries with periods less than 100 days, and 17 objects with periods larger than 100 days; he suggests that all members of close binaries in that temperature range have metallic-line spectra, perhaps because the slow rotation found in close binaries is necessary to produce the unusual metallic-line spectra.

In connection to the question of the rotational velocities of the Ap stars it is interesting to mention that E. N. Walker (1966*a*) in a recent discussion concludes that although some Ap stars may be seen pole on, Ap stars in general cannot be rapidly rotating normal A stars seen pole on.

Baschek and Oke (1965) have shown that after deblanketing corrections are introduced, the metallic-line A stars in the Hyades cluster lie to the left of the main sequence in the colour-magnitude diagram, and Strittmatter and Sargent (1966) find that the same is true for the metallic-line stars in the Coma and Praesepe clusters, which these authors interpret as being due to the slow intrinsic rotation of the metallic-line stars and in agreement with the theoretical result of Roxburgh and Strittmatter that suggest that, at a given colour, more rapidly rotating stars will appear more luminous.

Guthrie (1965*b*) has noted that there seems to be a preference for the manganese stars (it is not so among the silicon stars) to exhibit sharp lines; the difference between the silicon and the manganese stars may be related to the direction of the magnetic field relative to the axis of rotation.

Buscombe (1965*b*) has measured equivalent widths of Hγ and Hδ for a large number of stars in IC 2391 including several peculiar A stars.

At Odessa, Komarov (1965) finds that, on the average, the electron densities in the atmospheres of the metallic-line stars do not differ from those of normal main sequence stars of the same hydrogen spectral class.

(*k*) *Subdwarfs*

Warner reports work in progress on several southern F-G subdwarfs. Two galactic subdwarfs in the field of the Large Magellanic Cloud have been discussed by Thackeray (1966*a*).

D. S. Evans is working on a number of problems related to subdwarfs.

(*l*) *Faint Blue Stars*

Greenstein is continuing the low dispersion studies of faint blue stars, in an effort to obtain a more accurate estimate of the percentage of white dwarfs at approximately the 17th magnitude. The mean Einstein gravitational red shift of 53 white dwarfs have been measured by Greenstein and Trimble as $+51$ km s^{-1}, the mean for the DA stars being from $+56$ to $+62$ km s^{-1}. The derived mass of a helium core, about $0{\cdot}87\mathfrak{M}_{\odot}$, is roughly consistent with the photometric radii deduced from luminosities and colours. A further extension of the spectroscopic and colourimetric work by Greenstein and Eggen is resulting in a third list of white dwarfs which will bring the total of completely observed objects to 202.

Greenstein points out that the most interesting future problems will concern with hot white dwarfs with helium and carbon features and the possible effect of line blanketing on the colours of the red white dwarfs; for many of these no lines are visible but the radii deduced from the luminosity and the photoelectric colours are perhaps three times too large, it may be that they are hotter than they seem to be but their colours are perturbed by very greatly broadened lines, as Weidemann has suggested.

A surprising number of the faint blue stars show composite spectra (hot star + G star) and one faint object Ton 120 had broad emission like a U Geminorium star or an old nova.

The spectroscopic distinction between hot subdwarfs from very hot white dwarfs is difficult.

The H and He line widths among subdwarfs vary by large factors. Subdwarfs occur with He I and He II lines nearly as wide as in white dwarfs of type DB and DO and the Stark broadening suggests a range in luminosity by a factor of 1000. It is likely that the majority of the halo blue stars classified as Bp (presumably horizontal-branch stars) are helium-deficient objects.

Greenstein and Oke are continuing their study of horizontal-branch stars in globular clusters and have scanned 17 stars in M92 and several stars in M15. The gravities obtained suggest that these stars may not all have the same mass.

Bell and Rodgers (1964) have discussed the star L97-12; its spectrum appears continuous and the star may be dynamically related to the group of three λ4670 objects discussed by Bell in 1962.

Greenstein and Eggen's effort in finding new white dwarfs has resulted in the discovery of white dwarfs with small space motion that is of white dwarfs in the younger population indicating that extensive loss of mass can occur as evidenced by Sirius B.

Greenstein and Eggen have studied correlation between colour and spectrum: the cooler white dwarfs that still show H lines lie near $B - V = +0{\cdot}3$ magnitude and $U - B = 0{\cdot}5$ magnitude; the H lines are then extremely sharp, and deceptively weak, but this is not caused by low surface gravity alone but presumably by the depression of the ionization continuum, caused by high pressure.

(*m*) *Halo Population Stars*

Greenstein finds that the most single interesting star of the halo population yet observed is BD + 39°4926, a very metal-poor object with exceptionally strong neutral carbon and oxygen

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Under the current interpretation of nucleosynthesis theory BD + 39°4926 may be an object which has formed early and has synthesized its own carbon and oxygen or it may be one with very abnormal, selective, early composition.

(*n*) *Planetary Nebulae*

L. H. Aller has observed the nuclei of NGC40 and BD + 30°3639 with the Lick coudé and measured them with the spectrum scanner; he has also observed, at 16 Å/mm in the photographic region, the central stars of NGC6543, NGC6826, NGC6891 and NGC2392. Fainter nuclei have been observed with the Lick nebular spectrograph at the 3-m reflector: the central stars of NGC6853, NGC6058, IC3568 are essentially absorption-line objects while the nuclei of NGC6751, NGC6905, NGC7026 and IC1747 display interesting emission-line spectra of the Wolf-Rayet type.

F. Bertola (1964) gives the list of emissions in the Wolf-Rayet type nucleus of BAC209, the first one which does not show lines due to C.

C. R. O'Dell (1966) has studied M1-2 which were discovered and identified by Minkowski as a stellar planetary nebula; its spectrum may be explained as arising from a system of a G2 star and a hot companion but we could be dealing, according to O'Dell with a very peculiar single star.

(*o*) *Binary Stars*

Orbital elements in the following Wolf-Rayet objects, γ_2 Velorum (HD68273), HD193928, HD186943, HD211853, HD193576 have been determined by Vainu Bappu and Ganesh (1967*a*, *b*). The period derived for γ_2 Velorum is 78·5 days, which does not agree with the ones suggested by Sahade and by Gaposchkin (around 16 days).

Azimov (1965) has carried out a study of the subgiants components of RS Arietis, S Cancri, RS Canis Venaticorum, SX Cassiopeiae, GC Cassiopeiae, U Cephei, UX Monocerotis, RY Persei and I Sagittae, finding that the electron densities and the spectrophotometric temperatures are higher than those of single subgiants of same spectral types. Spectrophotometric gradients, temperature and physical parameters of the two components of AR Lacertae were also determined (Azimov, 1966).

Thackeray (1965*a*) has studied the spectra of the eclipsing system S Equulei and observed 'satellite' lines during eclipse probably due to gaseous streams; Thackeray's spectrograms are being investigated by Plavec.

Smak (1965) has been able to measure lines of Na I that belong to the secondary component of XZ Sagittarii and made a direct determination of the masses of the two components.

M. Spite-Lebon (1965) has determined the masses of the two components of χ Draconis and Bartoli *et al.* have studied BV382 Cephei.

Sahade (1966*a*) has extended his study of the spectroscopic binary HD698 on the basis of new Mt Wilson material by Jugaku and Sahade and confirms that the lines of the secondary component are absent from the spectrum, reaching the conclusion that the star is another system in which the mass of the fainter component is the larger; emission at Hα appears to arise from an expanding envelope around the system. The star (Sahade, 1966*b*) belongs to a group of systems with underluminous massive components (HD47129, AO Cassiopeiae, V453 Scorpii, V448 Cygni, β Lyrae and possibly ϵ Aurigae and W Crucis). One member of this group, V453 Scorpii, has been discussed in detail by Sahade and Frieboes-Conde (1965*b*).

An extensive study of the physical conditions in the atmospheres of HD47129 and AO Cassiopeiae has been undertaken by Galkina (1965, 1967); special attention has been given to the behaviour of the He II 4686 emission. The wavelength dependence of the depth of the eclipse of ϵ Aurigae during the 1955–57 minimum has been investigated by Ivanova; in long wavelengths there is almost no variation with wavelength.

The spectrum of β Lyrae in the visual region has been studied by Sahade and Hernández (Sahade, 1966*c*); full details will be published later. A new series of spectra of the same region of β Lyrae are being obtained by Batten at Victoria.

Feast (1967) has made a detailed spectroscopic study of the supergiant eclipsing system BL Telescopii, finding that the F-type primary has normal abundances though the *r*-process element europium may be overabundant; the secondary may be either a cool supergiant or a hot subdwarf ionizing a dense H II region. The spectroscopic changes during eclipse are interpreted as centre to limb variations of the primary. BL Telescopii is a 'run away' system and its present state is satisfied by the hypothesis that the secondary became of type II supernova 10^7 years ago. Further work on this system is in progress.

B. F. Peery, Jr. has published his detailed study of VV Cephei where he has found spectroscopic information that was interpreted as evidence of material falling upon the B component. Data on the 1955–57 eclipse of VV Cephei and later data are being studied by Wright (1966*a*).

Odgers and Wright (1965) studied multiple K-lines near the 1963–64 eclipse of ζ Aurigae and Wright is analysing similar data for the 1965 eclipse of 32 Cygni. During the 1963–64 eclipse ζ Aurigae has been also studied by Faraggiana (1965), and by Bardin and Prévot (1964*a*), while Scholz (1965) has measured the equivalent width of the K line in 32 Cygni, and Faraggiana and Hack (1965) have compared the spectra of the K-type component of ζ Aurigae, 31 Cygni and 32 Cygni.

Sahade in collaboration with Hernández, Faÿ and Cohen are carrying out a detailed investigation of δ Librae based on all available spectrograms.

At the David Dunlap Observatory Abhyankar obtained new spectroscopic orbits for S Coronae Borealis and HD 208392. Fletcher (1966) made a new study of the orbit of 47 Andromedae. Heard determined spectroscopic orbits for the W Ursae Majoris star V 566 Ophiuchi (1965), for the double-lined B0 IV system HD 217312 in the III Cephei Association (1966*a*), and for HD 131861 (1966*b*). Miss Northcott obtained spectroscopic orbital elements for the double-line binaries HD 15138 and 82780 and also for the double-line eclipsing system HD 200391, for which Bakos has also obtained the photometric elements.

At the Dominion Astrophysical Observatory orbital elements have been determined by Gutmann for ζ^1 Ursae Majoris (1966*a*) and υ Ophiuchi (1966*b*), by Thackeray and Tatum for HD 175544 (1966) and for 31 Cygni by Wright and Huffman. The study of the spectroscopic binaries HD 208947 and HR 8800 by the late R. M. Petrie, the latter with emphasis on the question of the apsidal motion, that were in a well-advanced stage at the time of his passing away, is being completed by Mrs Petrie.

Bidelman *et al.* (1963) have called attention to the fact that HR 4511 is probably a G-type supergiant spectroscopic binary.

A. P. and C. R. Cowley (1966) have reported changes in the spectrum of HR 8164 = Boss 5481 A which combines features of a sgM and of a B2 V objects.

D. S. Evans has continued his spectroscopic study of the interesting triple system p Velorum.

(*p*) *Miscellaneous Stars*

Webster (1966) has discussed some interesting emission line stars formerly classified as planetary nebulae; at least some of these stars seem likely to be symbiotic objects.

Feast is studying coudé of UY Centauri and several other similar stars.

L. H. Aller and Th. Dunham, Jr. (1966) have described the spectrum of η Carinae in 1961 and, except for a few changes, there is an agreement with Thackeray's 1951 observations.

Extensive work on η Carinae by Thackeray is reported under Commission 27. The same is true for the work done on RR Telescopii.

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Objective Prism Work

Objective prism surveys of the southern sky are being continued by Pik-Sin The and his collaborators. Among work in progress there are surveys for M stars in the direction of the south galactic pole, in Carina and towards the galactic centre.

Helium-Weak Stars

Greenstein, Sargent, Zirin and Heintze, Jugaku, Tsuji, Schadee and Boesgaard are devoting time to the problem of the apparently helium-weak stars.

Metal-Weak Stars

H. Bonel is attempting to discover at Michigan metal-weak stars on 10° objective prism plates; suspect ones are later observed with slit spectrographs.

High-Velocity Stars

BD + 37°442, discovered by Fehrenbach and his group, was studied by E. Rebeirot (1966); the star does not show H lines but does show strong ionized helium.

Globular Cluster Stars

Spectra of both the horizontal and the giant branches stars in NGC6397 have been obtained in Pretoria.

Novae

R. Goubrous (Helwan) has studied the behaviour of the H lines in Nova Herculis 1963 and Baschek (1964*a*) its near infrared spectrum; this has been followed by Y. Andrillat (1965*a*) from July 1963 to May 1965.

Batten (1964) has published results from the spectra of Nova Herculis 1963 taken between February and August, and Wright and Bochonko are preparing an atlas of the H line intensities from plates of 6 and 10Å/mm.

Nova Herculis 1963, of which Götz (1965), with the Sonnenberg Schmidt, had secured a spectrum on 2 September 1962, before the outburst, has been the subject of several investigations. At Abastumani Alania and Popov (1965) have obtained a large number of objective prism plates between 25 March and 9 September 1963, deriving an expansion velocity of 1190 km s^{-1}.

B. Folkart *et al.* (1964*a*, *b*) have produced two papers where the results of the measurements of the Balmer line profiles and of the narrow emission and absorption lines in RS Ophiuchi 1958 are given.

Cepheids

Warner (1964) has published a list of wavelengths and identifications in the bright cepheid *l* Carinae which should be generally useful for supergiants of about the same spectral type.

In Canada, Crompton has studied the spectrum of RU Camelopardalis which had been found by Demers and Fernie to have ceased its cepheid variation.

Alania (1965) have found that while the variations in spectral type of the short-period cepheid DX Delphini go from A8 to F8, the spectrophotometric gradient changes a little more that what it would correspond to the range in spectral types.

More information on cepheids will be found in Commission 27 report of the Committee on the spectra of variable stars.

Symbiotic Stars

M. P. Fitzgerald, N. Houk, S. W. McCuskey and D. Hoffleit (1966) give a preliminary line identification list of M H α 382-116 which appears to be similar to a symbiotic variable, spectrum wise.

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Long-Period Variables

A review article on the long-period variables including the discussion of some spectroscopic problems has been published by Smak (1966*b*).

Keenan, Deutsch and Garrison are undertaking a programme to observe the intensities of selected atomic lines and molecular bands in a number of the brighter Mira variables over several cycles and compare them with simultaneous photometric data obtained by other observers; the molecular bands under particular study include AlO λ4842 and YO λ6132.

Smak (1964) has discussed the effect of the TiO bands on magnitudes and colours of the Mira type stars as well as their position in the $M_{bol} - T_e$ diagram.

Alania (1966) has completed a study of the continuous spectrum of AC Herculis; at λλ4000–6000 Å the colour temperature varies from 4900° to 6800°.

(*q*) *Miscellaneous studies*

Rachkovskaya (1967) at Crimea has found that the spectra of the Ia-type variable stars AB Aurigae, V568 Cygni and *o* Herculis do not differ from the spectra of normal stars of same spectral type. Variations with time of the intensities of the emission and absorption components of the H lines were found in the spectrum of AB Aurigae.

Work on the MC Objects

Hutchings (1966) has measured Hγ equivalent widths for many stars in both Clouds and Thackeray (1965*b*) has studied spectroscopic changes in S Doradus.

Infrared Studies

Moroz (1966) has observed infrared spectra (1 to 2·5 μ) of 19 A1–M7 stars. Strong absorptions at 1·5 μ and at 2 μ which appear to be due to wings of stellar H_2O bands, were found in the spectra of the long-period variables *o* Ceti, R Aquilae and X Ophiuchi at light minima. A large number of fine absorption details due to CO were found in the spectra of K2–M5 giants. The energy distribution of red giants has a maximum at 1·6 μ, apparently due to the H- and H_2-ions.

Becklin at Caltech is determining infrared energy distribution out to 4μ for several infrared stars including an infrared object in the Orion Nebula that appears to have a blackbody temperature near 600°K.

McCammon, Neugebauer and Münch have obtained spectra of some of the extremely red objects discovered in the Infrared Sky Survey carried out at Mt Wilson. Among the interesting features found let us mention the sharp discontinuity at $\lambda = 1{\cdot}745\ \mu$ in the N-type stars Y Canis Venaticorum and U Hydrae.

Neugebauer and Münch have observed the spectrum of χ Cygni with the coudé 100-inch and a PbS detecting system.

Rotation

At Crimea, Boyarchuk and Kopylov (1964) have compiled a general catalogue of rotational velocities of 2558 stars, reduced to the Slettebak system. The catalogue is sufficiently complete for O5-G5 stars brighter than 5·5 magnitudes.

E. N. Walker (1965) has studied the variation of axial rotation with spectral type for main sequence stars within the range B9 to A5, and reached the conclusion that there is a preferential rotational velocity for stars of 2 $\mathfrak{M}_{\odot}$; the material comprises 633 stars.

Slettebak (1966*a*, *b*) has continued his studies on stellar rotation by investigating axial rotation in 56 later Be stars; the frequency distribution of rotational velocities of 42 of those stars suggests that all are rotating with an equatorial velocity near 350 km s^{-1} but have their

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rotation axes randomly oriented in space. Further, a comparison was made between the largest observed rotational velocities for stars of spectral types O 9·5–F0 and the computed equatorial break up velocities for stars of corresponding spectral types; and the region of minimum difference between the observed and the computed velocities is approximately that occupied by the Be stars.

Slettebak and Wright have estimated rotational velocities in 77 A-type stars near the north galactic pole and are carrying out studies of axial rotation in the Scorpio-Centaurus association and in *h* and χ Persei.

G. W. Collins II (1965) has extended and refined earlier work on the continuum emission from an early-type rapidly rotating star finding that a grey atmosphere is a moderately good approximation in the visible and a rather poor approximation in the ultraviolet where a variation up to 1·4 magnitudes in the colours, due to the effects of rotation, may be expected.

Collins and Harrington (1966) have computed Hβ profiles for rapidly rotating stars taking into account the effects of gravity darkening, limb darkening and shape distortion. In the range B0 V–B5 V considerable variation in shape with rotational velocity was found for the earlier types, while markedly variations of equivalent widths with rotation was found for the later types; calculations of Hγ profiles are near completion.

Andrews has measured the rotational velocities of B stars in IC2391, IC2602 and in the Scorpio-Centaurus association and was able to show that the faster rotators have the smaller Hα strengths, thus mimicking stars of higher luminosity.

Deutsch has examined the available statistics of rotational line widths at various spectral types along the main sequence and concludes that these statistics are fully consistent with a Boltzmann-type law for the distribution of angular momenta of stars. Deutsch and Kraft have accumulated some line-widths statistics for main sequence F stars.

Kraft and Wrubel have shown empirically that, at a given $B - V$, the slow apparent rotators of the Hyades show an ultraviolet excess relative to the fast rotators for spectral types between A8 V and F5 V, the amount of which is fully predicted by the change in surface brightness and effective temperature as computed by Sweet and Hogg. The implication that appears to result is that mild ultraviolet excesses for field F stars cannot be interpreted directly as evidence of metal deficiency unless the rotation is average to large for that spectral type.

Kraft has made an extensive study of $v \sin i$ in function of M_v for the stars of galactic clusters.

Kraft, C. Anderson and R. Stoeckly have redetermined the rotational velocities for stars in the Pleiades. On the basis of this work and the work of Abt and Hunter the suggestion is made that even after stars arrive on the main sequence, after gravitational contraction, there is still some slowing down of apparent rotation.

Baum, McGee and Kraft have made a study of rotational velocities for Praesepe stars using an electronographic image tube to obtain spectra of stars fainter than $M_v \sim +3$. The rotational velocities of all stars of very young I Persei (α Persei) group down to F5 V were studied by Kraft.

In a rediscussion of the rotational velocities of three T Tauri stars previously studied by Herbig, Kraft finds that angular momentum probably is not conserved for these stars as they contract to the main sequence along their Hayashi tracks. Spectrograms of stars of NGC2264 are obtained to check this point.

Kraft has studied in more detail the rotations of main sequence stars later than F5 V and finds a systematic tendency for higher rotations up to 25 km s^{-1} to occur among the younger dwarfs having K emission than among older dwarfs without K emission. Angular momentum among stars on the main sequence appears to decline with a time scale like that of the decay of stellar chromospheres.

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Analysing Slettebak's measures of $v \sin i$, Deutsch can distinguish, near A0, two groups of stars, one the 'Y' (or young population) which comprises about 80% of them, while the remaining 20% constitute the 'O' (old) population. According to Deutsch, the latter, sharp line objects, are on the main sequence for the second time and are metamorphs of originally massive main sequence stars that have lost substantial mass and angular momentum while in the red giant stage. The Ap stars—and similarly the Am stars—are the slowest rotations of the 'Y' population.

Walker and Hodge (1966) have measured equivalent widths and half-widths of the He I lines λ4388 and λ4471 as well as rotational velocities for 425 O9–B5 stars, and Deeming and Walker (1966) have made a statistical study of these data and also of Hγ-measures, and were led to propose a model in which atmospheric turbulence is generated in the equatorial region of a star as a result of rotation.

Turbulence

Conti and Deutsch (1966) have established that the weak-line and strong-line characteristics observed in stars result principally and directly from differences in turbulence and that the weak-line characteristic is very probably just the result of the systematic decay in the microturbulence of a star in a time scale that is short compared to its life time on the main sequence. Deutsch suggests that microturbulence decays for the same reason that chromospheric activity decays. O. C. Wilson has recently shown that this is due to a diminution of the non-radiative energy flux generated in the hydrogen convection zone: this flux excites microturbulence, chromospheric activity and a quasi-steady mass loss similar to the solar wind.

Conti and Deutsch have shown that in the disk population turbulence differences from star to star will change the line strengths in a way that produces ultraviolet excesses or other colour anomalies.

In short, turbulence may be more important than abundance anomalies in producing unusual colours.

In agreement with the above results, in a study of a cepheid of large light amplitude and weak lines, Abt *et al.* (1966) have found that the lines are weak because of low microturbulence rather than low abundances. This arises the question whether microturbulence in stars depends on the location of origin in the Galaxy.

Bonsack and Culver (1966) have determined widths at half-depth and equivalent widths of a selection of weak lines of neutral vanadium in the spectra of 58 stars of types G, K and M that include all luminosity classes, and found that the profiles of the weak lines in K stars are dominated by the motions of large elements of gas and that the velocities of these elements are correlated with stellar luminosity in the same way as are the phenomena at higher levels in the atmosphere which determine the widths of the K line emission and H α absorption.

By comparing the profiles and intensities of the lines with a theoretical model that represents the continuum spectrum, Underhill and de Groot (1964) concluded that the strongest lines in 10 Lacertae are enhanced by microturbulence, evaluated in 15 km s^{-1}, and that the He II intensities are influenced by turbulence and therefore are not good indicators of helium abundance.

Bell and Rodgers (1965) discussed turbulent velocities in the atmosphere of the supergiant δ Canis Majoris from equivalent widths, half widths and central depth measurements of the Fe I and Fe II lines. Microturbulence is of about 12 km s^{-1} for lines of all excitation potentials. Macroturbulence is also independent of excitation potential but probably depends on equivalent width.

Kopylov (1965) has determined the microturbulent velocities in the atmospheres of 68 O6–B5 type stars by the curve-of-growth method and the dependence of the microturbulent velocities with spectral type was analysed in a semiquantitative manner. A detailed analysis of

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the physical conditions in the atmospheres of 19 O-type stars have been carried out by R. N. Kumaigorodskaya (1965*a*, *b*) who found that the large scale motions exceeds those derived through the curve-of-growth method by a factor of 2 to 3.

Bell and Rodgers have also studied turbulence in the cepheid β Doradus (cf. Commission 27 report of the Committee on the spectra of variable stars), and Boyarchuk and Pronik (1965*b*) have found correlation between the turbulent velocity and the character of the H emission in the spectrum of ζ Tauri.

II. ABUNDANCE DETERMINATIONS

Just before the Hamburg General Assembly, a symposium on 'Abundance Determination in Stellar Spectra' was held in Utrecht. The proceedings of this symposium (IAU Symposium No. 26) have just recently been published as well as the proceedings of a conference on stellar evolution sponsored by the NASA Institute for Space Studies and held in New York in November, 1963, part of which deals with abundances (Stein and Cameron, 1966). A recent survey article by Cayrel and Cayrel de Strobel (1966) deals with many of the current problems.

(*a*) *Early-Type Stars*

Warner (1966*b*) has used his calculated *f*-values of Fe III to determine the iron abundance in γ Pegasi (B2 IV) using the equivalent widths measured by Aller and Jugaku in 1958 and an approximate solar abundance was found.

D. H. McNamara and Mrs L. Sivers are investigating the titanium abundance in the B3 star HD 37 058, the spectrum of which displays very strong Ti II lines at λ3759 and 3761, lines which are absent in other sharp-line stars of comparable spectral type.

L. H. Aller and J. Ross are concerned with A and B stars of peculiar chemical compositions and are reanalysing their vast high-dispersion material by using a better method of reduction of the plates and improved model atmospheres. Preliminary abundance analysis was carried out for v Herculis, χ Lupi, φ Herculis, ι Coronae Borealis, HR 8349, HR 7664, τ Capricorni, HR 6870 and ι Herculis. In all these objects, except for φ Herculis, for which no Sr, Y or Zr data are available, it is found that Sr, Y and Zr are greatly enhanced in abundance by factors ranging from 10 to 1000. Ti and Mn appear to be enhanced in v Herculis and the binary star χ Lupi—which has been studied in detail by Robert Wolfe—appears to be a heavy-metal star with prominent Hg, while in φ Herculis, Sc and Cr appear to be enhanced whereas Fe is nearly normal. Reanalysis is essentially completed for ι Coronae Borealis in which both Mn and Fe are substantially enhanced; Ti and Fe are enhanced by factors of 5 and 10 in the phosphorus star HR 8349 and HR 7664. Titanium may be also overabundant in τ Capricorni, whose spectrum is characterized by many weak lines. A remarkable star on the list is HR 6870 = HD 168 733 which has strong lines of chlorine; Fe which appears as Fe I, Fe II and Fe III, is enhanced about a hundred times, while titanium and strontium are increased by more than a thousand times over normal abundances. ι Herculis appears to have normal abundances although sulphur may be enhanced.

Conti has studied five extremely sharp-line A stars and found abundance differences that suggest relations with the 'metallic-line' stars of lower temperatures.

Buscombe is studying coudé spectra of southern OB stars with the aim of detecting possible differences in the He/H ratio, and is analysing χ Octantis (B8 V) and κ Eridani (B5 III) for abundances.

Hutchings is determining line intensities and Hγ profiles of several members of NGC 6231 and the results discussed in terms of model atmospheres and in conjunction with photo-electrically measured line intensities at Cambridge.

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Henry and Mihalas (1964) have made an extensive study of magnesium in many O9 V to A2 V stars, and find N (Mg)/N (H) = $2\cdot2 \times 10^{-4}$ with little scatter. This abundance is an order of magnitude greater than the solar value. In 10 Lacertae, Underhill and de Groot find a magnesium abundance lower by a factor of 10 than that of Henry and Mihalas. Underhill is trying now to determine from Fe III the iron abundance in 10 Lacertae.

An unsuccessful search for deuterium in B, A and F stars was carried out by Peimbert and Wallerstein (1965*b*); in some cases the upper limit is below the terrestrial value.

(*b*) *Helium-Weak Stars*

The important discovery of He^3 in 3 Centauri A by Sargent and Jugaku has been confirmed by Rodgers and Bell (1964), and from the line displacements of the helium lines in several B-type spectra, Gutmann (1966*c*) has concluded that He^3 is almost as abundant in ρ Leonis as in 3 Centauri A. The spectrum of η Leonis has been analysed by J. Hardorp (1963).

Bidelman (1965) has called attention to the variation with time of the strength of the helium lines in HD 125823 (=HR 5378), a member of the Scorpio-Centaurus association; this variation has been confirmed by Thackeray (1966*b*). The Jascheks (1967) have found Ga II in the star which they class with the helium-weak stars, 3 Centauri A, α Sculptoris, 36 Lyncis and α Cancri. The discrepancy between the spectral types of these objects, classified on the basis of the He lines, and their *UBV* colours is being used by the Jascheks at La Plata to search for more members of the group.

B. N. G. Guthrie (1965*a*) has studied some Be stars (HD 37051, α Sculptoris, 20 Tauri and 36 Lyncis) with weak He I lines for their intrinsic colours and strong Sc II, Ti II, Cr II, Fe II and Sr II and also HD 175156 where lines of He I, C II, N II, Mg II, Si II, Si III, S II, Ca II, Ti II and Fe II were identified and reaches the conclusion that the five stars are probably rapidly rotating stars of normal chemical composition viewed pole-on, the line strengths appearing abnormal only because the effective temperature and surface gravity are much higher at the pole than at the equator in rapidly rotating stars.

(*c*) *Hydrogen-Poor Stars*

Several hydrogen-poor, or helium, stars have been subject of investigation. A review article on these stars has been written by M. Hack (1966*b*).

Hill (1964, 1965) has analysed HD 168476, HD 124448 and BD + 10°2139 and the abundance of He, relative to the total mass of the atmosphere, corresponds to that expected for total H exhaustion. The abundance of O is only $\frac{1}{4}$ to $\frac{1}{3}$ normal while C and possibly also Ne and N are overabundant; other light elements appear normal. In HD 168476 the elements of the iron peak appear to be ten times overabundant but the lines of these elements may be formed in an outer cool shell.

HD 96446 has been analysed by Cowley *et al.* (1963) on the basis of high dispersion spectra, and a ratio of H/He $\sim 0\cdot38$ was found, line identifications of this star, which include 79 lines attributed to Kr II, have been given by Buscombe (1965*a*).

Warner has observed the four known H-deficient stars with constant brightness and is carrying out an abundance analysis.

(*d*) *Metal-Weak Stars*

M. Spite-Lebon (1965) has made a differential study, relative to the Sun, of χ Draconis A, a metal-weak star and the brighter component of a 280-day period spectroscopic binary, where she found that most of the elements are deficient by a factor of 2 (except calcium, manganese and barium) and that the age of the stars is the same as that of the Sun. Mme Spite-Lebon has determined the masses of the two components.

(*e*) *Metallic-Line and Peculiar A Stars*

A spectrophotometric investigation in the near infrared of metallic-line stars has led Praderie (1965) to the determination of the abundance of O, N and Mg in those objects. For the stars 63 Tauri, ω Tauri and τ Ursae Majoris the N abundance seems to be somewhat higher than in the Sun, while O appears to be relatively slightly underabundant, in agreement with an earlier result of Sargent and Searle.

In Pasadena, Subhash Chandra has examined the spectra, with particular attention, to the region $\lambda\lambda$3100–3700, of many relatively sharp-line Ap stars and found that strong lines of Be II are present in several Si-λ4200 stars as well as in most Mn stars and that a strong correlation appears to exist between the intensity anomalies in Ca II and Ba II and Mn II and Y II. Less pronounced correlations exist between other pairs of elements and in a number of Ap stars Chandra finds chromium lines (but not iron lines) that lie far below the flat part of the curve of growth in normal stars of the same temperature, and concludes that many abundances are really highly anomalous in Ap atmosphere but that the most conspicuous differences among the Ap stars may result simply from differences in temperature.

Conti (1965a) has studied the abundances in five metallic-line A stars in the Hyades relative to normal F stars in the cluster using semi-empirical model atmospheres. The abundances differences appear to be real: he finds calcium to be deficient, some elements lighter than iron underabundant and some heavier than iron overabundant. Conti (1965*b*) has also made a high dispersion spectroscopic survey of the sharp line early A stars brighter than 5·5 magnitudes and accessible from Mt Wilson and found that nearly half of them have the properties of the metallic-line stars that had been previously identified only in stars as early as A5. Among the stars that Conti finds that are metallic-line objects let us mention Sirius and 68 Tauri. Most of those stars are spectroscopic binaries. Conti's investigation have been extended, in collaboration with S. Strom, also to eight sharp-line early A stars in the Pleiades cluster, several of which appear to be metallic-line objects of early type.

K. Kohl (1964*a*) with the help of non-grey models have determined the abundances of 27 elements in Sirius and the conclusion is also that the star is a metallic-line object; he (Kohl 1964*b*) studied the spectrum of Sirius from 3100 to 8863 Å. Sirius has been also studied by Warner (1966*b*) who rediscussed the abundances of the iron group with the use of a semi-empirical model atmosphere; Warner has concluded that actually Sirius has some of the characteristics of a metallic-line star but the overabundances are less extreme than previously reported by others.

F. Praderie is making a detailed analysis of the metallic-line star ζ Lyrae A.

Searle and Sargent (1964) have compared Si II and Mg II lines in 31 Ap and five normal A- and B-type stars. These lines behave in a very similar fashion, are not sensitive to temperature or electron pressure changes, and therefore should indicate real abundance effects. Among the manganese stars they find silicon and magnesium normal. The stars of the manganese group were found by M. and C. Jaschek and González (1965) to have strong overabundances of Mn, Yt, Ga and Hg; He tending to be weak and Sr and Ti being generally overabundant though varying from star to star. Two stars of the 'λ4200' group (HD 173650 and 192913) were found to be iron-rich and also to have large overabundances of Si, Cr and Hg (M. Jaschek and Z. López García, 1966; A. D. Thackeray, 1966*b*; M. Jaschek, Z. González and C. Jaschek, 1965). The 'λ4200' stars, HD 34452, v Fornacis and 41 Tauri as well as the Cr-Eu star HD 2453, 25354, 42616, 71866 and 135297 are under investigation. Cl II has been found in HD 34452 (M. and C. Jaschek, 1967) and P II in HD 6822 (M. and C. Jaschek, 1964). A review of these investigations shows (1965*b*) that besides general group characteristics there are individual composition anomalies among stars that occupy nearby places in the two colour diagram, implying that there is no close correlation between colours and abundance anomalies.

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Mrs Z. López García (1966) studied γ Capricorni on the basis of high-dispersion material from Mt Wilson, and determined atmospheric parameters and found overabundance of Ti, Cr, Fe, Co, Sr, Y, Zr, Ba and La, underabundance of Sc and practically normal abundances of Mg, Ca, Mn and Ni. An investigation of the same star made earlier by Faraggiana (1964) on intermediate dispersion plates, had indicated an overabundance of some metals.

The abundances in the Mn star 53 Tauri has been revised by Warner (1965*a*) by using new *f*-values, and a new determination of the chemical composition of the star has been made by Guthrie (1966), by differential curve-of-growth method with α Lyrae as the comparison star, by using groups of lines of similar mean excitation and ionization potentials and wavelengths. It was found that Mn is overabundant by a factor of about 12, while Mg, Ca, Sc and Fe are deficient and the abundances of Si, Ti, Cr, Sr and Zr are about normal.

The peculiar A star HD 89822 (=HR 4072) found by Guthrie to be a double-line spectroscopic binary, was analysed by the same investigator from the point of the chemical composition resulting that for the brighter component Si, Mn, Sr and Y are overabundant by factors of about 20, 4, 90, and 200, respectively, while Sc is deficient by a factor of at least 5 and the abundances of Mg, Ti, Cr and Fe are about normal; the relative abundances of Ti, Cr, Fe, Sr and Y are similar in the two components.

Baschek (1964*b*) has determined the Na abundance in peculiar and metallic-line stars.

For the λ4200–Si II stars, silicon is overabundant by factors of 10 to 60 and the ratio of silicon to magnesium is 60 times the normal value, while the C II and He I lines are very weak suggesting abundance deficiencies. An analysis of the manganese star 53 Tauri by Aller and Bidelman (1964) indicates that manganese and gallium are very overabundant, strontium, yttrium and zirconium are somewhat enhanced.

L. H. Auer *et al.* (1966) have carried out a fine abundance analysis of 53 Tauri where they find that all of the metals lighter than titanium have normal abundances, and that He is underabundant by a factor of 5. From titanium onward, the elements show large overabundance factors, except for iron and chromium, both of which are normal; manganese is found to be 120 times overabundant.

Auer (1964) finds, in an analysis of 10 Aquilae, that europium, strontium, magnesium, manganese and cobalt are overabundant, while aluminium, scandium, zinc and barium are underabundant. Searle *et al.* (1966) have studied the iron-peak elements in 18 Ap stars. In manganese stars Mn/Fe is 6 to 60 times normal. The chromium to iron and titanium to iron ratios are abnormal and vary from star to star. In silicon-rich and oxygen-poor stars the iron-peak elements are in normal relative abundance. Wright (1965) has begun analyses of the Ap stars π^1 Bootis, HR 4072 and 49 Cancri. The star π^1 Bootis has strong lines of Ga II and Hg II. Yttrium is strong, but ionized lines of the iron group and rare earths are weak.

The Aop star ϵ Ursae Majoris has been analysed by Leushin (1965) at Crimea and physical conditions and relative abundances were determined, Ca deficiency being detected. Log *g* was found to be 3·5 from the Hβ and Hγ line profiles while the mass-radius relation gives a value of 4·4.

Yamashita (1966) has made an abundance study of the peculiar K-type star 37 Comae Berenices and compared its spectrum with those of the K giants χ and ψ Ursae Majoris; the abundance of Carbon in 37 Comae Berenices was found to be one-seventh the value found for the comparison stars.

In Pretoria Warner has obtained high dispersion spectra of a number of Ap and Am stars and abundances are being derived.

Hyland has in progress in Canberra a large programme of high dispersion spectroscopy and spectral scans of Ap and metallic-line stars in clusters and in the general field.

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A search for deuterium in magnetic stars (using the $H\alpha$ transition) by Peimbert and Wallerstein (1965*a*) was negative. They give upper limits for D/H of 7×10^{-4} to 4×10^{-5}.

e.1. Barium Stars

All the stars of this group have been studied by Warner (1965*b*) who finds carbon overabundant by factors 3 to 5, in agreement with previous determinations. The overabundance of heavy elements appears to be well explained by the *s*-process in nucleosynthesis. Danziger (1965*b*) has analysed the Ba II stars HD 116713 and HD 83548 finding somewhat greater overabundances. Among the light elements discussed by Warner and Danziger there is evidence for overabundances of Na, C and N. Warner has also derived absolute magnitudes from the H and K emission widths (Wilson-Bappu effect).

It is of interest to note that the problem raised by the large overabundance of Pr, an *r*-process element, in barium stars seems to have been solved in a theoretical discussion by Reeves (cf. R. Cayrel and G. Cayrel de Strobel, 1966).

In Japan, Nishimura is analysing the star HR 774 with the curve-of-growth method.

e.2. The Holmium Star HD 101 065

Przybylski (1966) has continued his work on the strange rare-earth star HD 101 065, where most rare-earth elements are very overabundant (by factors of 100 to 4000) although no evidence has been found for ytterbium. The question of lithium in this star has been considered by Warner (1966*c*) and is mentioned in the section on lithium abundances in stellar atmospheres; he is using $H\alpha$ profiles together with model atmosphere calculations to establish the absolute magnitude of the star. Przybylski who is studying HD 9996, a similar star to HD 101 065 but not such an extreme case, notes the possibility that HD 101 065 should be considered as a metal-poor star.

(*f*) *Late-Type Stars*

F. K. Edmonds, Jr. and S. Strom will do a fine analysis abundance determination for Procyon; Strom will furnish a non-LTE, line blanketed model atmosphere for the star.

G. Cayrel has determined the physical parameters and chemical composition of the atmospheres of seven stars of early K-type, as well as those of a comparison star (ϵ Virginis). Two of the stars are main sequence objects—HD 190404 and HD 219134—which were observed to try to solve the problem posed by O. C. Wilson as to whether the scatter observed on the colour-spectral type diagram for stars later tha G5 is due to chemical composition differences; the conclusion of Mrs Cayrel's study is that the two stars have the same chemical composition but that microturbulence is much larger in HD 219134 than in HD 190404 and this effect plus the temperature difference found to exist between the two stars, explains their colour difference ($B - V = 0{\cdot}82$ for HD 190404, and $B - V = 1{\cdot}02$ for HD 219134; O. C. Wilson's spectral types for the two stars being almost the same).

The rest of the stars investigated by Mrs Cayrel were giants of luminosity class III and II. A pair of them HD 48781 and HD 94264, classified as 'strong line' and 'weak line' stars, respectively, suggested that the chemical composition as well as other atmospheric parameters were identical in the two stars but microturbulence was smaller in the weak-line star. HD 6437, is metal deficient by a factor of 2 to 3; HD 6833, a typical halo object, is less metal deficient (on the average by a factor of 8) than the three halo K giants previously analysed by Greenstein and his collaborators, but metal deficiencies are not uniform from element to element; HD 35620 has an abnormal spectrum and yielded a slight underabundance of the metals by a factor of 3. In HD 6833 fairly strong interstellar D_1 and D_2 lines were found.

Baschek *et al.* (1967) have carried out a quantitative analysis of the spectrum of the F8 V star β Virginis, which has been described by Namba (1964) from λ3900 to λ6820 Å.

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Climenhaga (1965, 1966) has continued his studies of the C^{12}/C^{13} abundance ratio in late-type stars, and, from a study of the red bands, has determined the ratio for 19 Piscium, DS Pegasi and Y Canum Venaticorum.

Wright (1966) has obtained high-dispersion spectra for the G5 stars, 51 Pegasi and 20 Leo Minoris, for an abundance study.

At Canberra, Pagel has secured coudé spectra in the blue and red of a number of solar-type stars for which six-colour and other photometric data indicated that the metal abundance might differ from that of the Sun; these stars are α Centauri A and B, ρ Pavonis, HD 191408, α Phoenicis, ρ Tucanae, 82 Eridani and δ Pavonis); abundance analysis are in progress.

Conti and Greenstein, in co-operation with Spinrad, Vardya and Wallerstein have made an extensive study of O abundance using the [O I] lines at $\lambda\lambda$ 6300 and 6363. The observational data show a steady decrease of [O I] line strength with advancing spectra type and increasing luminosity; it is strongest in high velocity stars, which have a moderate metal deficiency.

Koelbloed has obtained at Mt Wilson spectra of G and K dwarfs, giants and supergiants for chemical abundance analysis.

Greenstein's programme on S-type variables has been supplemented with the observation of high-dispersion spectra of the bright, non variable S star, HR 1105.

Isotope ratios are being investigated by Schadee who has computed the shifts that according to theory should show the molecular bands. He is concerned at present with the search for Si^{28} and Si^{30} in HR 1105 and for Zr isotopes in R Andromedae.

Wyller (1966) has measured wavelengths of lines in the CN bands, particularly in the near infrared, to discover regions where the C^{12}/C^{13} ratio can be measured. In five carbon stars he finds this ratio to vary from 2 (in Y Canis Venaticorum and WZ Cassiopeiae) to 11; the equilibrium ratio for the CNO cycle being 3·4. Wyller suggests that C^{13} in carbon stars is partially synthesized by spallation and processes of neutron irradiation either in the atmosphere of Wolf-Rayet stars or in the carbon stars themselves. Schadee is studying the ultraviolet SiH bands in order to determine if the Si^{28}/Si^{30} ratio can be obtained. The same kind of analysis of the ZrO bands is used to determine how the Zr isotopes can be measured.

Mrs Locanthi has studied ZrO in R Andromedae and in V Cancri.

(g) *Giant and Supergiant Stars*

F. Spite (1964) has dealt with the method to approximately evaluate the metal abundances in some giant stars from low dispersion spectra by measuring the central depths of Hγ and of Ca I 4227.

Przybylski (1965) has made an abundance analysis of HD 33579, a giant in the LMC.

Zeinalov and Kopylov (1966) have made a detailed investigation of the physical conditions of the atmosphere and abundances in the supergiant η Leonis.

At Kiev M. Ja. Orlov (1966) has analysed the spectra of the M-type supergiant μ Cephei (λ 4250–6600 Å) and determined physical conditions in the atmosphere and abundances and discussed the relations between some parameters of the M-type supergiants.

At Crimea, M. E. Boyarchuk (1965) has studied the spectrograms of ρ Cassiopeiae, δ Canis Majoris and γ Cygni and found that in the atmosphere of ρ Cassiopeiae the abundance of the light elements was smaller and that of the heavy elements greater than in the atmospheres of the supergiants δ Canis Majoris and γ Cygni. A. Underhill is attempting to determine from Fe III the iron abundance in γ Pegasi and ρ Cassiopeiae.

(h) *Subdwarfs*

Danziger (1966) has carried out a curve of growth analysis of the bright southern late-type subdwarfs γ Pavonis and ρ^1 Reticuli. The results, which are compatible with *s*-process theory,

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indicate that the metals lighter than nickel are underabundant by 0·7 (in the logarithm) in γ Pavonis and by 0·4 in ρ^1 Reticuli while the underabundance of carbon is greater (1·3 in γ Pavonis and 0·8 in ρ^1 Reticuli). The relative abundance of Mn to Fe is normal in both stars but the heavy rare-earth metals are more underabundant than the iron group.

(*i*) *High-Velocity Stars*

Koelbloed has studied abundances in two weak-line stars of very high velocity, HD 2665 and HD 6755 on Palomar spectra taken by Greenstein.

HD 116745, discovered by Fehrenbach and Duflot, was found by Sargent (1965*b*) to be metal-deficient; the star must be highly evolved. Metal deficiency attains a factor of 40 in Wilson 10367 (LPM 661) as it results from the study made by Baschek (1965) in the ultraviolet and the blue.

Sargent *et al.* (1964) find a normal chemical composition in 7 Sextantis; earlier the star was supposed to be overabundant in helium and carbon.

At Pretoria, Peat has obtained spectra of six southern high velocity K giants in the 5000–6600 Å region and a detailed analysis is in progress; the low velocity K giant α Indi was observed as a comparison star.

Kodaira (1964) has determined the structure and chemical composition of HD 161817.

(*j*) *Globular Cluster Stars*

Searle and Rodgers (1966) have discussed 86 Å/mm spectra of horizontal branch stars in the globular cluster NGC 6397, finding that the metals are deficient by a factor of 100 while helium is deficient by a much smaller amount. They estimated the masses of these stars as 1·3 $\mathfrak{M}_\odot$.

Sargent (1965*b*) has studied Radcliffe spectra of HD 116745, the bright F-type member of ω Centauri, discovered by Fehrenbach and Duflot. The star was found to have the same Hγ profile and hence the same temperature as the normal F5 III star HD 113537, but to be deficient in Ca and Sr by a factor of between 25 and 60. Because of large number of Ti II lines in its spectrum, Sargent suggests that something more complicated than a simple general metal deficiency will have to be postulated for the star.

Observations of the horizontal-branch stars in globular clusters by Münch and of spectroscopically similar brighter objects in the galactic polar caps by Greenstein do not necessarily support the suggestion from theoretical work that the early He/H ratio was not much lower than it is now in B stars.

There have been several abundance analyses of field stars which are probably analogous to horizontal-branch stars in globular clusters. The early A-type star HD 109995 was analysed by Wallerstein and Hunziker (1964) who found a factor 10 metal deficiency, compared with the Sun. Kodaira (1964) obtained a metal deficiency by a factor 13 in the slightly cooler star HD 161817.

HD 26 and HD 201626, studied by Wallerstein and Greenstein (1964), are somewhat to the right of the vertical part of the globular-cluster giant sequence. They find metal deficiencies by factors of 5 and 30 respectively. In both stars the carbon to iron ratio is five times normal and barium, lanthanum, cerium and neodymium are up by a factor 20. Europium is higher than normal by only a factor 2 to 5. The abnormal abundances might be produced by helium burning followed by neutron addition to the iron-peak elements, followed by some mixing to the surface. Searle and Rodgers (1966) have obtained low dispersion spectra of horizontal-branch stars in NGC 6397; the metal-to-hydrogen ratio is down roughly by a factor 100 from the Snu.

(*k*) *Halo Population Stars*

Spectroscopic studies of faint stars in the galactic halo have been pursued by Greenstein (1966). He finds He I and He II lines enhanced by factors of 3 to 5 in sdB and sDO stars. He I lines are weakened by a factor 3 in Bp stars. Berger (1963) and Sargent and Searle (1966) have found groups of hot halo stars in which the He I lines are weak and the hydrogen lines are strong compared with those in normal stars of the same colour and Balmer discontinuity.

W. L. W. Sargent and L. Searle (1966) have compared Feige 11, 36 and 65 stars with τ Scorpii and concluded that at least the three halo stars are helium-deficient, a rough estimate being on those objects where the He/H ratio is lower by a factor of 100 than it is in main-sequence stars of Population I.

B. Pagel (1965*a*, *b*) has derived heavy metals abundance in HD 122563 finding that the ratio Fe/H is about 250 times weaker than in the Sun; relative to the Sun there is a deficiency of barium, cerium and europium.

(*l*) *Miscellaneous Stars*

Two main sequence stars of same spectral type and different age, HR 2217 B and χ Bootis B, were observed by Bardin and Prévot (1964*b*) and found to have identical chemical composition in their atmospheres.

Danziger (1965*a*) has analysed the star RY Sagittarii which is similar to R Coronae Borealis; the abundance ratio of carbon to hydrogen is 25 and the ratio of carbon to iron is 35 times normal while sodium and lithium abundances are high.

l.1. *Cepheids*

In the report of Commission 27 the abundance work on the cepheid β Doradus is discussed.

Kraft and Abt have studied TV Camelopardalis and found that abundance is normal to within a factor of about 2, and that the cause of the weak lines is a low turbulent velocity.

l.2. *Binaries*

A new discussion on β Lyrae from the point of view of the chemical composition is due to Hack and Job (1965).

In regard to the subgiant components of Algol systems it is important to mention an investigation that is being carried out by D. S. Hall who has found, using narrow band photometry technique, that there may be an underabundance of CN in the mentioned components.

Sargent (1966) has analysed both components of ADS 3910, finding that one component is a typical B5 V star and that the companion is deficient in helium by a factor of 100 and in iron and silicon by a factor of 10; the latter star has probably suffered surface activity and may be related to the λ Bootis stars.

(*m*) *Lithium Abundances in Stellar Atmospheres*

Herbig has devoted most of his time to the problem of lithium in F-K stars and its implications. In a first paper (1965) he is concerned with dwarfs in the F5-G8 range; these stars show rather high Li abundances suggesting that convective depletion of Li during contraction cannot have been completed in the mass range concerned and that the variations in Li abundance in F5-G8 dwarfs may be due to a slow process of convective depletion. In a paper on the lithium abundances in F-G and K type subgiants, written in collaboration with R. J. Wolff (1966), it is suggested a mechanism of Li depletion through mass loss which is age-dependent and does not involve continuous Li burning at the base of the convection zone.

A programme that Herbig is carrying out at present is that of Li abundance in the later-type component of composite systems, usually G-K + B-A types.

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The problem of the correlation of Li abundance with intensity of H, K emission cores is being dealt with by Herbig by means of an extensive programme of spectrophotometry of the emission cores at 8 Å/mm, mainly in F-G dwarfs.

Wyller is concerned with the problem of lithium in carbon stars on account of possible C^{13} N^{14} line contamination in the calcium and lithium lines used for differential comparisons. The results of his study will be presented at the Joint Discussion in Prague on the lithium problem.

Wallerstein *et al.* (1965) have looked at 23 stars in the Hyades and find lithium to calcium ratios from 3 to 100 times that in the Sun. For $B-V \geqslant 0{\cdot}61$ the abundance is correlated with temperature, again suggesting destruction by convection into the interior. Further, Wallerstein (1966*a*) has measured the same ratio in 5 F-type and 6 G-type giants; the F giants show large enhancement of lithium while the G-stars do not. The F component of Capella has 60 times the lithium abundance of the G-star. The change in depth of the convection during the star's evolution is again responsible for the large differences.

In order to test Herbig's theory in regard to correlation between a star's lithium content and age, Wallerstein (1966*b*) has observed visual binaries in which at least one component is of a sufficiently late spectral type (F0 V) that the resonance line of neutral lithium might be present. Six out of nine very young systems have a high lithium content and the upper limits on the lithium content of the other three systems are not in serious disagreement with Herbig's hypothesis. However, several subgiants have a substantial lithium content, in contradiction with Herbig's correlation. As a consequence, Wallerstein suggested a possible mechanism in terms of internal magnetic field that might assist in the preservation of lithium.

Some carbon stars have lithium to calcium ratios ten times larger than in the Sun while others show no lithium (Torres-Peimbert *et al.* 1964).

Rodgers and Bell find the abundance of lithium to be more than ten times the solar value in the 35-day cepheid *l* Carinae. Also an overabundance is found by Danziger and Oke (1966) in VZ Cancri a metal-deficient cluster-type variable. The presence of lithium in this presumably highly evolved star is surprising and suggests that surface reactions may have occurred.

Lithium is one of the few cases where atomic lines show isotope shifts large enough to be measured: the shift between Li^6 and Li^7 is 7 km s^{-1}. Herbig (1964) observed 15 F- and G-type stars and found appreciable Li^6 in a few of them. A substantial extension of this early work on Li isotope ratios in F-K subgiants is in progress, with some improvements in technique.

In two Hyades F-type stars Merchant *et al.* (1965) found no evidence for Li^6. Wallerstein (1965) finds that two metallic-line stars have more Li^6 than similar normal stars and suggests the possibility of spallation reactions. In the sunspot spectrum Schmahl and Schröter (1965) found $Li^6/Li^7 \approx 0{\cdot}05$.

A high dispersion coudé programme in progress at Pretoria, being carried out by Feast, aims at determining the Li abundance and the Li^6/Li^7 ratio in a variety of southern stars. Among them the bright subgiant β Hydri — a member of the ρ Herculis group — with a general metal deficiency of about 2 or 3, according to Rodgers and Bell (1964), a Li/Ca ratio ten times the solar value and a high Li^6/Li^7 ratio (Feast 1967). The Li^6/Li^7 ratio appears to be high for lithium-rich subgiants and low for main sequence stars possibly implying lithium production during evolution off the main sequence.

Warner (1965*c*) has discussed a method of deriving lithium abundances from Li I equivalent widths.

Conti and Danziger have studied further the decrease of lithium with age in field stars and in the Pleiades, and found no difference in the pre-main sequence depletion and that the depletion time scale in G stars seems to be of the order of 10^9 years. The F stars appear to have a considerable range of initial abundance of Li.

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The fact that no beryllium has been found in A or F supergiants led Conti to think that evolution might be from right to left in supergiants. He found no beryllium in the G subgiants η Bootis and ζ Herculis, making its presence in δ Eridani even more surprising.

A comparison of the beryllium and lithium abundances in ten F- and G-stars has been made by Merchant (1966) who found a much smaller range of abundances in beryllium than in lithium.

M. Bretz (1966) is interested in the presence of lithium in S stars: no lithium was found in the nine bright stars between types M and S that were studied, except perhaps in HD 30959.

JORGE SAHADE
President of the Commission

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APPENDIX I: REPORT ON ABSOLUTE SPECTROPHOTOMETRY

(Prepared by J. B. Oke)

Since the last IAU meeting in Hamburg, little fundamental absolute calibration work has been carried out. Material discussed at that time has now appeared in print. Willstrop (1965) has published energy distributions of 215 stars of types O5 to M4 with measures made over successive 50-angström bands from λ4000 to λ6900. He also made comparisons with standard lamps. A sequence of early-type stars near the celestial equator and suitable for absolute spectrophotometric standards has been measured by Oke (1964). All stars have been observed from λ3390 to λ5900 and some out as far as λ10800. It now appears likely that in this list all the absolute spectrophotometric magnitudes below the Balmer jump should be made fainter by approximately 0·06 magnitude on the basis of the best absolute data now available for α Lyrae. Aller, Faulkner, and Norton (1964, 1966) have published absolute fluxes for more than 20 southern stars. They have been tied to the standards of Oke (1964).

The remaining papers on absolute spectrophotometry have been primarily for the purpose of determining fundamental data about stars, i.e. log T_e and log g. These are used to determine accurately the locations of stars in the Hertzsprung-Russell diagram and for obtaining the parameters needed in chemical abundance analyses.

Glushneva (1964) has obtained absolute energy distributions of 14 B 9 to A 7 and seven earlier-type stars from λ3000 to λ4700, using photographic slitless techniques. More recently four additional early-type stars have been studied (Glushneva, 1966). Oke (1965) in a review article discussed some of the observational problems associated with absolute spectrophotometry and gave energy distributions for a number of stars. Baschek and Oke (1965) have measured 11 Am, Ap, and normal A stars from λ3400 to λ10800. Measures have been corrected for absorption lines and a temperature scale is given. Oke and Conti (1966) obtained continuum energy distributions from λ3400 to λ10800 for 24 Hyades stars of spectral types A3 to K0. The relation of $B - V$ to log T_e is given. Whiteoak (1966) obtained absolute fluxes from λ3448 to λ10500 for 38 early-type stars to study the interstellar extinction law. Oke, Greenstein and Gunn (1966) obtained and discussed energy distributions of a number of suspected field horizontal branch stars. Karetnikov and Medvedev (1966) have described a new spectrometer and published energy distributions from λ3800 to λ5800 of α Andromedae, β Arietis and α Cygni. Baschek, Oke and Searle (unpublished) have obtained absolute energy distributions from λ3400 to λ10800 of all known λ Bootis stars.

Aller and Faulkner (1964) obtained spectrophotometric data for the WR star γ Velorum. Kuhi (1966) obtained absolute fluxes from λ3200 to λ11000 of many nothern WR stars. He finds high colour temperatures in the blue and violet and lower ones in the visual and red. Kupo (1965) obtained gradients and Balmer jumps around the cycle of β CMa. Oke (1966) has obtained similar data for the very metal-deficient RR Lyrae star X Arietis.

Rodgers and Searle at Mt Stromlo have scanned η Carinae and discovered a red continuum similar to that of the nucleus of the Seyfert galazy NGC4151 and to the Crab nebula. Comparison of absolute Hα fluxes and radio-thermal emission in the surrounding H II region leads to a value of A_V/E_{B-V} of 6.

In the infrared, Woolf, Schwarzschild and Rose (1964) using Stratoscope II obtained scans from 0·8 to 3μ of 6 K- and M-type stars. These were all compared directly with the A1 star α Canis Majoris. Low and Johnson (1964) have extended their broad-band photometry out to 10μ. They now have sufficient infrared points to represent at least approximately a large part of the spectral energy distribution of cool stars. Wildey and Murray (1964) have also made measurements of 25 stars at 10μ. Johnson (1965) has obtained broad-band colours out to 3·5μ of 43 K- and M-type stars. Mendoza and Johnson (1965) obtained colours out to 10μ for many carbon stars.

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After the report by Dr Oke was written the following additional information was received:

Žilevičiute and Straižys (1965) have studied the energy distribution in the continuous spectrum of γ Cassiopeiae during 1964–65.

The energy distribution in the continuous spectrum of RW Aurigae has been studied by Mirzoyan and Kazarian (1965) and by Kharadze and Bartaya (1965). A more or less intense UV-continuous emission is permanently present in the stellar radiation and the energy distribution changes conspicuously with light variation.

At Alma-Ata the work of establishing spectrophotometric standards is in progress. Karjagina and Haritonov (1964) have made absolute measurements of flux at different wavelengths for a number of stars and published results for 34 stars. Haritonov (1964, 1966*a*) has published absolute measurements for 17 field stars and for 14 Pleiades stars (1966*b*).

Haritonov and Neljubin (1966) have made absolute measurements of the fundamental star α Lyrae, calibrating with the integral flux from the centre of the solar disk.

Noskova (1965) has found that the energy distribution of the nuclei of the planetary nebulae NGC40, 3242, 6210, 6543, 6572, 7009, 7662, IC2149, 4593 and BD + 30°3639 is similar to that of a black body.

Glagolevsky (1966) has studied the energy distribution of magnetic and Ap stars and found that on the average the spectrophotometric gradients and the Balmer discontinuities differed from those of normal A stars.

At Alma-Ata, Kozlova and Glagolevsky (1966) have investigated the energy distributions in the continuous spectra of 40 Ap and Am stars within the range $\lambda\lambda$3200–5000 Å and concluded that these stars have the same anomaly in their continuum and that such an anomaly might be connected with the same anomaly in the structure of the atmosphere.

Energy distributions have been measured by Aller in the $\lambda\lambda$3300–5800 range for the following stars: 2 Coronae Borealis, ζ Virginis, HR4072, 15 Cancri, 53 Tauri, η Virginis, HD144206, 112 Herculis, HR8349, τ Capricorni, φ Herculis, ι Herculis, HR8348, π_1 Bootis.

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G. Cayrel and A. M. Fringant (1964) have given the results of a spectrophotometric study of two metal deficient stars, HD 221 170 and HD 122 563, which show a difference in blue gradients that suggests a local difference of the absorption coefficient.

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APPENDIX 2: REPORT OF THE COMMITTEE ON LINE INTENSITY STANDARDS

(Prepared by G. Cayrel de Strobel, Chairman of the Committee)

During the XIIth IAU General Assembly (Hamburg 1964), K. O. Wright and G. Cayrel de Strobel prepared a list of 20 astronomers who could possibly collaborate in the working group on Line Intensity Standards of Commission 29. These astronomers have been chosen either because of their previous interest in this problem, or because they have high dispersion equipment at their disposal. To these astronomers, G. Cayrel de Strobel sent a circular letter on 31 March 1965 explaining the ever present difficulties of systematic discordances in equivalent widths obtained from different spectrographs.

G. Cayrel de Strobel suggested in her circular the observation of five standard stars with a dispersion equal to or better than 12 Å/mm on II-aO, II-aD, and II-aF plates. These stars are: γ Pegasi B2, 5 IV, 68 Tauri A2 V, 15 Vulpeculae ML, α Canis Minoris F5 IV and ϵ Virginis G9 III.

For calibration, a double calibration has been suggested: one with the local system and one with the Kienle step-filter, which could be sent from one observatory to another.

A list of reasonable unblended lines was enclosed in the circular in order to define not only standard stars, but also preferred standard lines to be used for comparison.

The following remarks are based upon the replies to the circular, made either in writing or in person. Five astronomers did not reply at all.

H. A. Abt (Kitt Peak Observatory) answered only recently that he agreed to collaborate but has not yet begun to observe any of the requested stars.

A. A. Asaad (Helwan Observatory, Cairo) has used the 74-inch coudé spectrograph of the Helwan Observatory to obtain spectra of the five programme stars.

W. Buscombe (Mt Stromlo Observatory) did not answer, but L. Searle promised to observe some of the programme stars with a dispersion of 2·8 and 6·7 Å/mm with the 74-inch coudé spectrograph of Mt Stromlo Observatory. By the way, L. Searle found that the line-intensity programme is too heavy. He believes that three stars would be enough, and he suggested: γ Pegasi B2·5 V, α Canis Minoris F5 IV, and ϵ Virginis G9 III. He thinks also that the number of standard lines for each emulsion should be reduced and called attention to the fact that the circular did not mention the number of plates for each emulsion. He suggested two plates.

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R. Cayrel and G. Cayrel de Strobel (Haute-Provence Observatory) sent a graduate student, Miss C. Moreau, to the Haute-Provence Observatory to work on the programme. C. Moreau has observed three stars: 68 Tauri, 15 Vulpeculae and α Canis Minoris. The results obtained are contained in her 'diplôme d'études supérieures' (1966). This work will appear in the *Journal des Observateurs* and an abstract is given here:

68 *Tauri A2 V*

The relation between the equivalent widths of 68 Tauri obtained from spectra taken at Victoria (Wright *et al.*, 1964) and the equivalent widths of 68 Tauri from spectra taken at the Observatory of Haute-Provence (OHP) is given by the formula:

$$W\left(\frac{\text{Victoria}}{3{\cdot}4\,\text{Å/mm}}\right) = 0{\cdot}89\,W\left(\frac{\text{OHP}}{9{\cdot}7\,\text{Å/mm}}\right) + 4$$

The comparison between Lick equivalent widths of 68 Tauri taken from Conti *et al.* (1965) and OHP ones gives

$$W\left(\frac{\text{Lick}}{10{\cdot}5\,\text{Å/mm}}\right) = 1{\cdot}31\,W\left(\frac{\text{OHP}}{9{\cdot}7\,\text{Å/mm}}\right) - 45$$

15 *Vulpeculae M L*

$$W\left(\frac{\text{Victoria}}{7{\cdot}5\,\text{Å/mm at H}\gamma}\right) = 0{\cdot}89\,W\left(\frac{\text{OHP}}{9{\cdot}7\,\text{Å/mm}}\right) + 9$$

$$W\left(\frac{\text{Victoria}}{2{\cdot}8\text{ and }3{\cdot}4\,\text{Å/mm}}, \frac{\text{Palomar}}{4{\cdot}5\,\text{Å/mm}}\right) = 0{\cdot}90\,W\left(\frac{\text{OHP}}{9{\cdot}7\,\text{Å/mm}}\right) + 2$$

$$W\left(\frac{\text{Mt Wilson}}{2{\cdot}8\text{ and }4{\cdot}5\,\text{Å/mm}}\right) = 1{\cdot}04\,W\left(\frac{\text{OHP}}{9{\cdot}7\,\text{Å/mm}}\right) - 18$$

In the two first relations, the equivalent widths of Victoria and Palomar have been taken from K. O. Wright *et al.* (1964) the last one from G. R. Miczaika *et al.* (1956).

α *Canis Minoris F5 IV*

For α Canis Minoris, C. Moreau compared equivalent widths obtained from 3·2 Å/mm OHP spectra with those obtained from 9·7 Å/mm OHP spectra. She obtained:

$$W\left(\frac{\text{OHP}}{3{\cdot}2\,\text{Å/mm}}\right) = 0{\cdot}95\,W\left(\frac{\text{OHP}}{9{\cdot}7\,\text{Å/mm}}\right) + 5$$

Then she compared the following sets of equivalent widths

$$W\left(\frac{\text{Victoria}}{7{\cdot}5\,\text{Å/mm at H}\gamma}\right) = 1{\cdot}17\,W\left(\frac{\text{OHP}}{9{\cdot}7\,\text{Å/mm}}\right) + 6$$

$$W\left(\frac{\text{from Hiltner and Williams Atlas}}{2{\cdot}8\,\text{Å/mm at H}\gamma}\right) = 1{\cdot}04\,W\left(\frac{\text{OHP}}{9{\cdot}7\,\text{Å/mm}}\right) + 46$$

$$W\left(\frac{\text{McDonald}}{2{\cdot}8\,\text{Å/mm at H}\gamma}\right) = 1{\cdot}18\,W\left(\frac{\text{OHP}}{9{\cdot}7\,\text{Å/mm}}\right) + 17$$

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$$W\begin{pmatrix}\text{Bergedorf}\\ 8\,\text{Å/mm at } H\gamma\end{pmatrix} = 0{\cdot}90\, W\begin{pmatrix}\text{OHP}\\ 9{\cdot}7\,\text{Å/mm}\end{pmatrix} + 46$$

$$W\begin{pmatrix}\text{Asiago}\\ 12\,\text{Å/mm at H}\gamma\end{pmatrix} = 1{\cdot}28\, W\begin{pmatrix}\text{OHP}\\ 9{\cdot}7\,\text{Å/mm}\end{pmatrix} + 22$$

The equivalent widths from Hiltner and Williams, McDonald, Bergedorf and Asiago have been taken from Hiltner and Williams (1946 *Photometric Atlas of Stellar Spectra*), Greenstein (1948), Wellman (1955) and Taffara (1953).

The spectrophotometric calibration has been checked by C. Moreau with the help of Kienle's step-filter. No significant difference was found with the current calibration obtained at the OHP. In the case of α Canis Minoris it is likely that the differences found in equivalent width measurements do not come from photographic effects (Edmonds, 1965; Moreau, 1966) but from the rather subjective way in which the continuum is located and the wings of the lines are drawn. In this connection the following remark can be made: C. Moreau measured a certain number of lines of α Canis Minoris on the Hiltner and Williams atlas. Greenstein independently did the same. The two sets of measurements compared with the OHP measurements are quite different. This result does not involve different instruments but only different personal judgements. By the way, Greenstein and Hiltner (1949) found that the equivalent widths obtained from the Hiltner and Williams atlas should be reduced by about 8%.

G. Cayrel de Strobel has compared equivalent widths from nine spectra of ϵ Virginis taken at Mt Wilson Observatory (Cayrel, G., Cayrel, R., 1963) with those from 11 spectra taken at the Observatory of Haute-Provence (Cayrel de Strobel, 1966). She found:

ϵ Virginis G9 III

$$W\begin{pmatrix}\text{Mt Wilson}\\ 1{\cdot}0 \text{ and } 2{\cdot}8\,\text{Å/mm}\end{pmatrix} = 0{\cdot}90\, W\begin{pmatrix}\text{OHP}\\ 9{\cdot}7 \text{ and } 12{\cdot}4\,\text{Å/mm}\end{pmatrix} + 8$$

C. and A. Cowley (McDonald Observatory) have agreed to observe some standard stars with the McDonald 82-inch coudé spectrograph. In the meantime, equivalent widths of α Canis Minoris measured chiefly on 4·8 Å/mm McDonald coudé spectra have been published by F. N. Edmonds (1965). The comparison between McDonald equivalent widths of α Canis Minoris spectra, and the means of equivalent widths found by K. O. Wright for α Canis Minoris from Victoria and Mt Wilson spectra, gives:

$$W\begin{pmatrix}\text{McDonald}\\ 4{\cdot}8\,\text{Å/mm}\end{pmatrix} = 0{\cdot}97\, W\begin{pmatrix}\text{Victoria} & \text{Mt Wilson}\\ 4{\cdot}6 \text{ and } 2{\cdot}2\,\text{Å/mm}, & 2{\cdot}9\,\text{Å/mm}\end{pmatrix} + 5$$

and the comparison between McDonald and OHP gives

$$W\begin{pmatrix}\text{McDonald}\\ 4{\cdot}8\,\text{Å/mm}\end{pmatrix} = 1{\cdot}06\, W\begin{pmatrix}\text{OHP}\\ 9{\cdot}7 \text{ and } 12{\cdot}4\,\text{Å/mm}\end{pmatrix} + 11$$

This last result relies unfortunately on a very scarce number of lines (seven lines).

V. Fujita (Tokyo Observatory) wants to collaborate and is eager to receive the step filter to check Tokyo's calibration system.

L. Gratton (Laboratorio de Astrofisica di Frascati-Roma) has not yet any high dispersion equipment at his disposal, but he comments on some of his previous works (Gratton 1953). The equivalent widths of the K2 III p Star α Bootis obtained from McDonald spectra do agree with those of Victoria, but do not agree with those obtained from the Hiltner and Williams atlas. Gratton does not believe in continuous calibration systems but prefers step filter. For high dispersion analysis on G and K stars, he does not trust dispersion less than 10 Å/mm.

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J. L. Greenstein (Mt Palomar and Mt Wilson Observatories) transmitted the circular to P. S. Conti, who sent to G. Cayrel de Strobel a few interesting comments but did not say anything about a collaboration on this programme. Conti (1965) found that the equivalent widths of 45 Tauri dF4 from 10 Å/mm Mt Wilson spectra were systematically stronger by 15% than those from 10 Å/mm Lick spectra. Wallerstein and Conti (1964) found also that the equivalent widths of the Ko III giant γ Tauri from 15 Å/mm Mt Wilson spectra were 5% stronger than the Mt Palomar ones (dispersion 13·5 Å/mm) and 25% stronger than the Lick ones (dispersion 16 Å/mm). Helfer and Wallerstein (1964) have compared equivalent widths from 6·0 and 6·7 Å/mm spectra of ϵ Virginis with those obtained by the Cayrels (1963) on 2·8 Å/mm spectra, and they did not find any significant differences.

G. Herbig (Lick Observatory) agreed to collaborate, but on a less heavy programme. He would like to observe one or two stars out of five and to measure a few lines out of the proposed one. Until now only 68 Tauri among the five standard stars has been observed (Conti *et al.*, 1965), and some of its equivalent widths have been measured on Lick 10·5 Å/mm spectra. The comparison between these equivalent widths and those of the Observatory of Haute-Provence has already been quoted.

J. Houtgast (Utrecht Observatory) is always interested in the problem of line intensity standards, but thinks that at Utrecht, he cannot help with it at the present.

B. E. J. Pagel (Herstmonceux Observatory) will collaborate on this programme, but only with blue plates, and will take 10 Å/mm spectra of the standard stars. The dispersion in the red and yellow region is below the requested limit. In his letter Pagel also suggests that spectra be taken of integrated sunlight from sky, Moon or minor planets with the equipment of each of the collaborating observatories. The different set of equivalent widths should then be compared with the excellent photoelectric measurements of MacMath (see for example Müller and Mutschlecner, 1964) which can be converted into values for integrated sunlight by a very simple numerical quadrature. This procedure will tell what is really wrong with everybody's equivalent widths, rather than merely how much they disagree with each other.

J. Sahade (La Plata Observatory) has not yet any high dispersion equipment at his disposal in Argentina but is willing to collaborate securing programme stars spectra whenever he would have observing runs at Mt Wilson. This would be indeed very welcome.

A. D. Thackeray (Radcliffe Observatory) will try to collaborate and take some 6·8 Å/mm spectra in the blue region of a few programme stars, but he does not have facilities for measuring the lines equivalent widths from the plates. G. Cayrel will try to find a student to do this work in Paris.

S. Taffara (Asiago Observatory) found a young astronomer, P. L. Bernacca, who is willing to observe the programme stars and measure the equivalent widths of the requested lines. The calibration system of Asiago has already been checked with Kienle's step filter a few years ago.

K. O. Wright (Victoria Observatory) has done the most accurate and extended work on line intensity standards which has ever been done (Wright *et al.*, 1964). Equivalent widths measured on Victoria, Mt Wilson and Mt Palomar spectra, of twelve main sequence stars Bo to G5 have been compared. The spectral range has been 3900 to 4500 Å, and the number of lines measured passed 500 in the F type stars. The results are already contained in Wright *et al.* (1964) and in the Transactions of the 12th IAU General Assembly. In spite of his already impressive contribution, Wright will collaborate on this programme and get some spectra of the requested stars with a better resolution than the resolution of the spectra he used in his former study. Wright found also that the combination of a II-aD plate from 4800 to 6200 Å with a II-aE plate from 6200 to 6600 Å gives approximately the right density all along the plates whereas the II-aF is a little too weak.

Regarding Pagel's suggestion of using the solar spectrum as a standard, Wright suggests the use of planetary or asteroid spectra. He fears that the spectrum of the daytime sky light may be affected by scattered light.

Some Conclusions on Line Intensity Standards

There is a statement one can make: until now we have not been able to give any easy correlations between the values of equivalent widths obtained with one instrument and the values obtained with another.

K. O. Wright gave us (Taffara, 1962) the correlations between Victoria, Mt Wilson and Mt Palomar, but every time we reduce new material we have to check: (1) if, between the equivalent widths coming from different spectra taken at the same instrument, there are not big systematic differences; (2) if the mean of equivalent widths of the new material has the same value as the mean formerly found for this instrument.

From the paper by Wright *et al.* (1964) we see that the equivalent widths obtained from photoelectric scans are in good agreement with those obtained by photographic means. They tend to be slightly larger than those obtained by Wright and Greenstein at Mt Wilson, but almost coincide with the photographic means of equivalent widths measured on high dispersion spectra.

In the near future it will be necessary to pass slowly to the technique of observing one or two standard stars and of comparing the equivalent widths obtained by photographic means with those obtained from spectrophotoelectric scans. Therefore we suggest that we ask the observatories which already have spectrophotoelectric equipment to scan the standard stars we shall propose. Once we obtain equivalent widths from photoelectric scans of different instruments, we have to see if they agree with each other. This set of equivalent widths will then be compared with the photographic measurements of equivalent widths obtained from high dispersion spectra with different instruments.

The programme has been regarded as too heavy by almost every co-worker. Therefore, it would be perhaps more practical to reduce the programme to one star and the solar spectrum for which excellent photoelectric measurements do already exist.

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