29. STELLAR SPECTRA (SPECTRES STELLAIRES)

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In my task, I have asked the help of the Vice-President, of the members of the Organizing Committee, and of the Chairmen of four Working Groups to prepare the reports of the work done in the Southern hemisphere, Europe (except U.S.S.R.), U.S.S.R., North America, the work done on A-type stars, Of and WR stars, and binary stars, and activities of the Working Groups. I am very grateful to all who sent me the reports for their help. However, I feel that it would have been more efficient if I could have asked those people who helped me for reporting on the subjects, each of which may be the most adequate specialized item for certain person. Although there must certainly be better ways of doing it, the report has been divided in many sections according to the main subject. The report reflects the enormous amount of work in the field of stellar spectroscopy done in the last three years. I am afraid if I have missed to note some important work carried out.

Since the last IAU meeting 29 has co-sponsored the following meetings: IAU Symposium No. 49 on *Wolf-Rayet and High Temperature Stars* (Buenos Aires, Argentina, August 1971); IAU Symposium No. 51 on *Extended Atmospheres and Circumstellar Matter in Spectroscopic Binary Systems* (Struve Memorial) (Parksville, Canada, August 1972); IAU Symposium No. 54 on *Problems of Calibration of Absolute Magnitudes and Temperatures of Stars* (Geneva, Switzerland, September 1972); IAU Colloquium No. 17 on *Stellar Ages* (Meudon, France, September 1972); IAU Colloquium No. 19 on *Working Conference on Stellar Chromospheres* (Greenbelt, U.S.A., February 1972). The thanks of the committee are due to their representatives on the Organizing Committee of these meetings. Besides, it should be remarked that two meetings were held in connection with stellar spectra: *International Astronomical Symposium on Astronomical Spectra in the Infrared and Microwave Regions* (Liège, Belgium, June 1971); *Colloquium on Supergiant Stars* (Trieste, Italy, September 1971).

It is stimulating to learn that much spectroscopic work is going on in the Southern Hemisphere. Particularly, photoelectric and photographic coudé spectroscopy at the Cerro Tololo Inter-American Observatory is planned to obtain line profiles for the brighter southern stars of early type. Spectra of some stars on a series of high dispersion spectrograms obtained at the European Southern Observatory are studied in some institutions.

It may be worth-while to note the instrumentation in stellar spectroscopy. Cayrel reports in connection with this problem that digitized microphotometers have improved in several observatories the possibilities for fast and accurate reduction of spectra. At the same time it became necessary to develop an appropriate software and to investigate the new possibilities open by a digitized form, as noise filtering and more elaborate information recovery techniques.

Golay presented at the IAU Symposium No. 54 the report on 'Remarks on the photometric criteria of choice of the standard stars'. This includes a list of stars to be observed both by photometrists and spectroscopists. *Information Bulletin*, No. 1 ~ No. 3 published by Jung in Observatoire de Strasbourg may also benefit spectroscopists.

Of AND WOLF-RAYET STARS

IAU Symposium No. 49 on *Wolf-Rayet and High Temperature Stars* was held at Buenos Aires in August 1971. The papers presented form a comprehensive assessment of present status of work on Wolf-Rayet stars and related objects.

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1. *Of stars*

Johnson (*Ap. J.*, **176**, 645) has examined the Of star HD 148937 by the techniques of narrow band photometry. He confirms an absolute visual magnitude of -6. All peculiarities point to instability of massive, hot star with non-uniform mass loss of visible ejecta, over a long period into a total volume of 10^5pc^3. A spectrographic study is under way at Victoria of the extreme Of star HD 108. Image Isocon observations are also being made of the Of star HD 188001 and 210834 to detect time changes in emission lines. Baschek and Scholz (*A.A.*, **15**, 285) report new observations of the line spectrum of ζ Pup (O5f) from λ 3160 to λ 8600.

Line intensity. Brucato (*M.N.*, **153**, 435) finds He II λ 4686 and N III λ 4634–40–41 in the Of stars HD 108, 188001, 190429, 192639 and 210839 to vary in intensity with time scales of the order of 10 min, with the most striking changes occurring at λ 4686 in the earliest spectral types. Heap (*A.A.*, **15**, 77) finds that time profiles in the spectra of Of stars of Populations I and II do not compare well with those computed for a classical LTE model atmosphere. The chief difference between young and old stars is the relative strength of the C III and N III lines near λ 4650. Heap (*Ap.L.*, **10**, 49) finds in the case of ζ Pup that taking due account of the spherical symmetry resolves the conflict between excitation temperature and the effective temperature deduced from the flux envelope. Mihalas and Lockwood (*Ap.J.*, **175**, 757) made scanner observations of He II λ 10124 in O and Of stars. In the Of stars the λ 10124 line is in emission. It is suggested that the Of emission lines are a manifestation of a chromospheric phenomenon. Swings reports that teams at Liège, Montpellier and Marseille have in progress programs of Of stars to gain a better understanding of the behaviour of the emission and absorption features of N III, C III, He II etc. The program includes the examination of planetary nuclei with WR and Of stars. Morton, Jenkins and Macy (1972) report that rocket spectra of the O7.5I star ζ Per in the λ 1130–2070 domain show P Cyg profiles indicating mass ejection. The absorption components of resonance lines of N V, Si IV and C IV have violet shifts of 1840 km s^{-1} while an absorption line from an excited state of N IV at λ 1719 has a violet shift of only 287 km s^{-1}.

Mechanism. Brucato and Mihalas (*M.N.*, **154**, 491) have made a statistical equilibrium calculation to examine the mechanism of N III λ 4634–41 emission in Of stars. They find that the Swings mechanism of the lines arising in a circumstellar shell by virtue of pumping in the ultraviolet λ 374 and λ 452 transitions is as most likely. Nussbaumer (*Ap.J.*, **170**, 93) explains the N II and C III emission in Of stars to be caused by population of the upper levels by absorption of continuous stellar radiation. Mihalas (*Ap.J.*, **170**, 541) interprets the broad emission component near λ 4634–4640 as observed by Wilson and Underhill by the stabilizing transition from the N III autoionizing term $2s2p(^1P^0)\,3d^2F$ to the bound double-excitation term $2s2p(^1P^0)\,3p^2D$. Mihalas *et al.* (*Ap.J.*, **175**, L99) show by detailed non-LTE calculations that the N III emission lines at $\lambda\lambda$ 4634, 4640, 4641 observed in Of stars are produced primarily by dielectric recombinations.

2. *Wolf-Rayet stars*

Kuhi and Smith are preparing an Atlas (as an NBS special publication) of Wolf-Rayet spectra from spectrograms of dispersion 16 Å mm^{-1} in the blue and 32 Å mm^{-1} in the red. They plan to provide intensity tracings in a loose-leaf form of at least one star of each sub-class WN3–WN8 and WC5–WC9. Bappu and Scaria have ready for press (*M.K.O.*) intensity tracings from plates of dispersion 10 Å mm^{-1} in the blue and 20 Å mm^{-1} in the red of the stars HD 50896, 165763, 191765, 192103, 192163, 192641, 193077, 193576, and 193793. Galkina (*I.C.A.O.*, **41**, 283) pointed out that the emission lines in the spectrum of HD 193793 have different profiles. The line profiles of lower ionization are flat topped while those of higher ionization are rounded. She concludes that atoms are moving away with acceleration. Seggewiss at Bonn has studied the binary HD 152270 in the region λ 3600–6000. An interesting result of this study is that the values of the systematic velocity as derived from C III λ 5696 of the WC star and the Balmer absorption lines of the companion are identical, contrary to the 'red shift' normally seen in WR stars with measures made in

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the blue region of the spectrum. Niemela reports finding variable radial velocities for HD 90657 and 93131. She finds HD 92740 to be a binary with a period of 10·04 days. Niemela and Sahade (*O.*, **90**, 198; **91**, 220) have suggested new criteria to detect binaries among the WR stars.

γ^2 *Vel.* Bappu and Rajamohan find that the violet displaced λ 3888 line in γ^2 Vel shows a remarkable periodicity in exhibiting sharpness around zero phase and a splitting around phase 0·25. The zero phase sharpening is confined to about a day around the precise phase. Conti and Smith (*Ap.J.*, **172**, 623) find in γ^2 Vel that the O star is brighter than the WR by 1·4 mag. Rajamohan finds the difference 1·0. The absorption line intensities in the blue region and emission lines in the infrared are both combined to yield this value.

Cowley *et al.* (*A.A.*, **11**, 407) have derived a spectroscopic orbit for CV Ser with an improved orbital period of 29.706 days. The similarity of the 1970 observations to earlier data suggests that there is no spectroscopic evidence that the orbit has changed in any way. The eclipses in the C III emission line (Tcherepaschuk, *A.Zr.*, No. 509) are seen when the companion is behind the WR star. The single deep minimum observed by Hjellming and Hiltner in 1962 corresponds to the phase when the WR star is behind the companion. The star warrants a combined spectroscopic and photometric study of emission lines and continuum. Wray and Corso (*Ap.J.*, **172**, 577) have identified 25 objects in M33 to be WR stars on the basis of narrow-band interference-filter photography. Spectra of two of these objects are of types WC5 or WC6 + OB. Crampton (*M.N.*, **153**, 303) has compiled a catalogue of WR stars coincident with H II regions. Approximately 44% of the WR stars surveyed are found to be possibly associated with nebulosity. The absolute magnitudes of the galactic WR stars are 0·8 mag. fainter than those derived from WR stars in the Large Magellanic Cloud. A reference must be made in this connection to Smith's exhaustive discussion (IAU Symposium No. 49, *Wolf-Rayet and High-Temperature Stars*, 1973, p. 17). Cherepashchuk *et al.* (*A.Z.*, **49**, 533) have shown that the envelope of WR star V 444 Cyg is disturbed by effects of the nearness of the O6V component. The radiations of ions with $\chi > 60$ eV have considerable concentrations to the WR core.

Bertola and Ciatti (*Liège Colloquium*, 1971) have carried out observations in the λ 6000–11000 region with an S-1 image tube of 11 stars of the WN sequence and 6 stars of the WC sequence. Bappu and Scaria (*K.O.B.*, No. 210) have results in the λ 6000–8800 region of 8 stars. Allen, Swings and Harvey have observations of the northern WR stars at 1·6 μ(H) and 2·2 μ(K). The H-K colours are redder than the values expected from their atmospheric temperatures. The measures effectively separate the WN from the WC stars since the WC stars are systematically redder than the WN stars. A similar survey in the southern hemisphere by Allen and Porter substantiates the results from the north, but show up two exceptions, γ^2 Vel and θ Mus, that were uncommonly blue around 2 μ. Underhill finds that WC spectra may result from plasmas with electron temperatures less than 10^5 degrees while WN spectra require electron temperatures near 10^5 degrees. The density in the dominant line emitting region is of the order of 10^{11} to 10^{12} particles per cm^3. The optical spectra of galactic WR stars, central stars of some planetary nebulae and of Sco-X-1 and WX Cen have much in common. Castor and Nussbaumer (*M.N.*, **155**, 293) have employed the spherical expanding envelope model to find equivalent widths of C III lines in the rocket ultraviolet of WR stars.

O, B STARS

1. *O stars*

Spectrum. Baschek and Scholz (*A.A.*, **11**, 83) measured equivalent widths of absorption lines of the O component of the spectroscopic binary γ^2 Vel (WC8 + O8). They (*A.A.*, **15**, 285) studied the line spectrum of ζ Pup. Spectroscopic properties of Of and O stars are compared by Heap (*A.A.*, **15**, 77). She showed that present temperature scales for O5–O8 stars should not be applied to Of stars until the effect of gravity in determining spectral type has been determined. Kodaira, Baschek and Scholz compared the strengths of the absorption lines of HD 188209 (O9·5I) with those of the MKK standard ζ Ori A, to find out that nitrogen lines are definitely strengthened in HD 188209, the helium lines slightly, while the carbon lines are slightly weakened. Thackeray

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(*M.N.*, **150**, 215) studied the single-lined O6 binary HD 49798 and confirmed Jaschek's conclusion that the primary is a hot subdwarf.

Atmospheric parameters. Richter (*A.A.*, **14**, 415) tried quantitative analysis of the O subdwarf HD 49798 and obtained atmospheric parameters such as T_{eff}, $\log g$, $\log \varepsilon_{He}$ and $\log \varepsilon_{N}$ with LTE-models. Dufton (*M.N.*, **159**, 79), however, shows that equivalent width and line profile data obtained for HD 49798 cannot be explained on the assumption of LTE. Comparison with the results of non-LTE calculations produces the atmospheric parameters $T_{eff} = 45000 \pm 5000$ °K and $\log g = 4{\cdot}3 \pm 0{\cdot}3$. The ionized helium line wings are considerably stronger than the non-LTE calculations predicted with normal abundances and this is interpreted as evidence of a helium overabundance by a factor of 5. Tomley (*Ap.J.*, **162**, 239) carried out a model-atmosphere analysis of the hot subdwarf HD 127493, and the subdwarf components of the binaries HD 128220 and HD 113001. Besides the He enhancement there is an indication of definite rearrangement of the CNO abundance for HD 127493 and HD 113001, and of a possible mild rearrangement of CNO in HD 128220.

Non-LTE. Dufton (*M.N.*, **159**, 79) reports the observations of the O-type subdwarf HD 49798. These observations cannot be explained on the assumption of LTE. Zinn (*Ap.J.*, **162**, 909) has shown that the equivalent width of Hβ is nearly constant from B0V to O5. This result supports the non-LTE model-atmosphere computation of Mihalas and Auer. Peterson and Scholz (*Ap.J.*, **163**, 51) studied spectra of 6 O-type stars (O9·5 V–O5) by means of LTE model atmospheres. Appreciable departures from LTE occur as predicted by Mihalas and Auer. Most elements have abundances close to solar values, but Ne is overabundant.

2. *B, Be stars*

Spectrum behaviour. Behaviour of hydrogen lines is one of interesting aspects in B type stars. The widths of the hydrogen emission lines of 26 Be stars were measured by Doazan (*A.A.*, **8**, 148). Values of Balmer decrements for 55 Be stars were obtained by Briot (*A.A.*, **11**, 57). Observation of the Hγ profile in the supergiants β Ori, η CMa, o^2 CMa and ε Ori as well as observations of the confluence of the Balmer series by Underhill (*A.A.*, **6**, 114) should be remarked. Kogure and his colleagues are continuing the study of the Hα and Hβ emission intensities of Be stars. Underhill *et al.* (*Ap.J.*, **171**, 63) suggest that a broad absorption feature centered near λ 1720 observed by OAO-II may be a useful indicator of early-type supergiant and shell stars.

Variations in the spectrum of B stars have been observed. Le Contel *et al.* (*A.A.*, **8**, 29) observed them in the β CMa star HD 43818. Hubert (*A.A.*, **11**, 100) did the same on 3 Be stars from 1953 to 1970. Hutchings *et al.* (*Ap.J.*, **170**, L73) find rapid changes in the Hα line profile in some Be stars. Van der Wel (*A.A.*, **4**, 341) studied variation of line profiles for the shell star ζ Tau.

Spectrophotometric observations have been carried out at the European Southern Observatory on 75 bright main sequence B2–B5 stars by Sinnerstad. Kodaira (*Ap.J.*, **159**, 931) observed 27 B3V stars.

Jascheks are continuing the survey for early B type stars with spectral anomalies. They found the star HD 148688 the first oxygen rich star so far known and the super-supergiant HD 152236 a spectrum variable. The He I line behaviour was observed by Leckrone (*A.A.*, **11**, 387) and Narrio and Scholz (*A.A.*, **13**, 359). Van Helden (*A.A.*, **19**, 388) found two new He I lines λ 8776·74 and λ 8528·65 in the spectra of supergiants of spectral type B5Ia to B0Ia.

Molnar (*Ap.J.*, **175**, 453) tried an extensive spectral classification of He-weak stars and a quantitative analysis of 7 of them is carried out. Conti (*Ap.J.*, **159**, 723) found no evidence of detectable fields in Zeeman measures of He-weak B stars. Model atmosphere computations have been carried out by Norris (*Ap.J.S.*, No. 197) to intensities of He I lines for normal stars and weak-He-line stars.

Andrillat and Houziaux (*Ap. S. S.*, **15**, 236) investigated the continuous spectra of the Be stars HD 50138 and 51585 in the near-infrared region λ 7000–9600. The difference in the infrared gradient from that of the normal BV stars is interpreted by the interstellar reddening and reemission in an envelope.

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Other spectroscopic observations have been carried out by Monteagudo and Sahade (*B. A. A. A.*, No. 15) on γ^2 Vel, by Gobroo (*S. A. J.*, **14**, 356) on the Be variable HD 217050, by Bond and Landolt (*P. A. S. P.*, **83**, 485) on the subluminous B-type CD–42°14462, by Caputo and Viotti on a P Cyg star AG Car.

Chemical composition. Baschek and Norris (*Ap.J.*, **159**, 1130) find from the analysis of B subdwarf HD 205805 that atmospheric He abundance is smaller by a factor of 10 than that of the Population I star γ Peg. Baschek *et al.* (*Ap.J.*, **173**, 611) find from the analysis of B subdwarf HD 4539 that the He/H ratio is lower than normal by a factor of 16. The N/H ratio is higher than normal by a factor of 3 and the O/H ratio is lower than normal by a factor exceeding 10 while the C/H ratio is normal. Danziger (*Ap.J.*, **161**, 997) obtained from halo B HD 137569 the normal abundance of He and C, and certainly a low abundance of Mg and Si. Wolborn (*Ap.J.*, **176**, L119) finds in the spectroscopic binary HD 16318 N enhanced and extremely deficient in C and O. He suggests those anomalies are due to material processed through the CNO cycle in one of the massive components. Dufton (*A. A.*, **16**, 301) finds early B type supergiant HD 164402 has a normal composition while HD 96248 is underabundant in N and Ne by factors 3 and 6 and possibly overabundant in Mg and Si. Comprehensive study on the weak-helium line star α Scl (B5, B8III) by Vilhu (*A.A.S.F. Series A*, **6**, 394) shows that He is underabundant by a factor of nearly 10.

Stars in which abundance determination has been carried out are β Her, η Hya and HD 58343 by Kodaira and Scholz (*A.A.*, **6**, 93), ε Ori by Lamers (*A.A.*, **17**, 34), 33 main sequence B stars by O'Mara and Simpson (*A.A.*, **19**, 167), β Her by Peters and Aller (*Ap.J.*, **159**, 525), β Cep stars by Watson (*Ap.J.*, **169**, 343), 29 Psc by Klinglesmith (*Ap.J.*, **171**, 79).

Radial velocity. Kodaira (*P.A.S.J.*, **23**, 159) measured the radial velocity of 25 northern bright B3V stars. Of these 25 stars, 18 are suspected to have variability in their velocity. The measurements of the radial velocity for lines produced by the envelope of the Be star HD 217050 were carried out by Granes (*A.A.*, **19**, 224) and Fehrenbach (*A.A.*, **19**, 427).

Envelope. Delplace (*A.A.*, **7**, 68) determined the profile of the Be star HD 37202 ζ Tau in order to estimate the contribution in emission and absorption of the envelope of this star. He (*A.A.*, **7**, 459; **10**, 246) discussed instabilities in the envelope of the same star. The Hβ profiles and pulsation of the envelope of the Be star HD 218393 were studied by Doazan (*A.A.*, **2**, 245). Sahade and Albano (*Ap.J.*, **162**, 905) present evidence for the existence of an expanding envelope around the system υ Sgr. The observed pattern of differential line shifts in the spectrum of β Ori by Chentsov and Snezhko (*S.A.J.*, **15**, 429) can be explained by a radial expansion of the star's atmosphere. Hutchings extended his study to stellar envelopes. The paper on γ Cas (*M.N.*, **150**, 55) deals with its extended envelope and the paper on HD 109378 and 142926 (*M.N.*, **152**, 109) deals with their rotationally extended envelopes. Hutchings and Wright (*M.N.*, **155**, 203) studied rotationally extended envelope of the Be component of VV Cep. Hutchings and Laskarides (*M.N.*, **155**, 357) analyzed the spectra of the shell star HD 187399 and gave a model for the stellar envelope. Kogure is studying shell spectrum and outer envelopes of Be stars. Marlborough (*Ap.J.*, **159**, 575; **163**, 525) calculated the profile of the Hα line and other Balmer lines based on the model envelope

Physical parameters. A method is discussed of deducing the gravity of an early-type star from the strength of the [HeI] λ 4045 line by Dufton (*A.A.*, **18**, 335). Norris (*Ap.J.S.*, No. 197) determines effective temperatures, gravities and apparent He deficiencies for 12 weak-helium-line stars. Absolute magnitude of early B star γ Vel was determined by Baschek (*A.A.*, **7**, 318). Kodaira (*Ap.J.*, **159**, 931) determined the effective temperature of 25 bright B3V stars. The effect of rapid rigid rotation on weak and intermediate strength lines in early type spectra is investigated by Hardorp and Strittmatter (*A.A.*, **17**, 161).

Old disk horizontal-branch stars 7 Sex and 38 Dra were investigated by Rogers and Wood (*Ap.J.*, **161**, L145) and Adelman and Sargent (*Ap.J.*, **176**, 671) respectively with respect to the abundance problem. The spectra of two blue-horizontal-branch stars in ω Cen are discussed by Rogers (*Ap.J.*, **171**, 257).

Low-dispersion spectral survey of some horizontal-branch stars has been carried out by Philip *et al.* (Philip, *P.A.S.P.*, **82**, 69; **83**, 154; *A.J.*, **75**, 524, 957; Philip and Tifft, *B.A.A.S.*, **2**, 337).

3. *OB stars*

Line profiles. Buscombe (*Stellar rotation colloquium*, 115) measured line strengths for OB stars and obtained stellar rotation. Detailed measures of the profiles of the first four hydrogen lines in the Balmer series for 23 southern stars are listed by Buscombe (*M.N.*, **148**, 75). Buscombe (*M.N.*, **148**, 79) observed emission features on spectrograms of intermediate and high dispersion for 57 southern OB stars. Detailed profiles of Hβ and Hγ, Hα for the shell stars o Aqr and ε Cap and a list of sharp absorption lines due to metallic ions in the shell of ε Cap are listed. Van Blerkom (*M.N.*, **149**, 53) shows that the rectification procedure having been asked for separating emission and absorption components of P Cyg-type line profiles yields an underestimate of the absorption component and distorts its profile. Norris and Baschek (*Ap.J.S.*, **19**, 305) present line profiles of neutral helium for a grid of approximate line-blanketed model atmospheres. Walborn (*Ap.J.*, **161**, L149) reports that in some of OB stars the nitrogen lines are too strong or too weak for their spectral types. Further Walborn (*Ap.J.*, **164**, L67) reports that several OB stars show nitrogen-carbon anomalies analogous to those among the WR stars. Herbig (*Ap.J.*, **169**, 537) observed the near-infrared (λ 6500–8500) spectrum of LkHα-101. In the near-infrared the spectrum contains many narrow emission lines of H, O I, [O II], [Fe II], [Cr II], and a number of unidentified features. Klinglesmith *et al.* (*Ap.J.*, **159**, 513) made a fine analysis of hydrogen-deficient star σ Ori E and obtained model parameters. Except for the deficiency of hydrogen, there appear to be no conspicuous abundance anomalies.

Departure from LTE. Hearn (*M.N.*, **150**, 227) showed that the variation in the He absorption lines of main sequence early-type stars could result from varying degree of the departures from LTE. Poland and Skumanich (*M.N.*, **152**, 18p) comment that, although the cores of some lines exhibit non-LTE effects, their equivalent widths, which are dominated by line wings that remain in LTE, are unaffected and yield the same He abundance as in LTE. Shipman and Strom (*Ap.J.*, **159**, 183) calculated non-LTE of He I. In relation to those researches, Hearn (*M.N.*, **155**, 3p) shows that there is in fact agreement in general terms that in B type stars some strong He I lines are affected by departures from LTE which cause serious errors in the He abundance, while in some other lines those effects are negligible.

He star. Helium-rich single-lined spectroscopic binary, HD 30353 is also known as hydrogen deficient early type. Nariai (*P.A.S.J.*, **24**, 495) has clarified this star shows a P Cyg type profile of Hα when the primary is farthest from us while Hα appears only in emission at other phases. This is the same phenomenon as that observed in the spectrum of another hydrogen-deficient binary υ Sgr which was investigated by Nariai (*P.A.S.J.*, **22**, 559). Hill (*O.*, **90**, 10) estimated the upper limit to the oxygen abundance in the helium star HD 168476. MacConnell *et al.* (*P.A.S.P.*, **82**, 730) found 6 new stars showing unusually strong He I lines on southern objective prism plates. It is interesting to note survey of helium weak stars is under way (Jaschek *et al.*, *B.A.A.A.*, No. 15).

A-TYPE STARS

1. *Normal A stars*

Spectral classification. A catalogue of spectral types, luminosity classes and *UBV* colours has been published by Cowley *et al.* (*Ap.J.*, **74**, 305; **75**, 941). Bertaud (*A.A.S.*, **1**, 7) has prepared a catalogue of spectral types of 112 A and F stars. Barry (*Ap.J.S.*, **18**, 281) classified about 160 A and F stars. Bolton (*A.A.*, **14**, 233) shows that small dispersion spectrograms can be used for classification and for discrimination of Am stars. Pesch gives spectra, luminosity and radial velocity for 86 B8-A3 stars.

Energy distribution, effective temperature and gravity. Breger and Kuhi (*Ap.J.*, **160**, 1129) obtain the effective temperatures and gravities for 8 variable and 12 non-variable A and F stars by a spectrum scanner. A similar study has been made by Dickens and Penny (*M.N.*, **153**, 287). Absolute energy distribution for α Lyr has been measured by Oke and Schild (*Ap.J.*, **161**, 1015; **166**, 95) by a photoelectric spectrum scanner, and the effective temperatures for A and B type stars determined

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by the continuum-flux observations. Stickland (*O.*, **90**, 206) derives energy distribution for MK standard main sequence stars and derives effective temperatures. Stickland (*A.A.*, **10**, 478) also derived the effective temperature in the spectral range A0-G2. Baylac (*A.A.*, **16**, 85) derives the effective temperature of A stars by the V-I index of Johnson. Zverks (*B.A.I.* **22**, 49) has made a quantitative analysis of α Cyg.

Microturbulence. Elste and Ionson (*B.A.A.S.*, **3**, 380) discuss how the new *gf* values (Wolnick *et al.*, *Ap.J.*, **162**, 1030; **166**, L31) affect microturbulence in A-type stars. An extended study of microturbulence in A stars has been made by Smith.

Rotation. Danziger and Faber (*A.A.*, **18**, 428) analyze stellar rotation among evolved A and F stars. Abt and Hudson (*Ap.J.*, **163**, 333) studied rotational velocities in short period A binaries.

Variability. Le Contel *et al.* (*A.A.*, **8**, 159) study the weak short time variations of the contour of the K-line in γ Boo (A7 III).

Chromospheres in A-type stars. The problem of the existence of a chromosphere in A-type stars is studied by Praderie and coworkers. UV observations by means of data from OAO II are studied by Gros and Sacotte and Sacotte (*IAU Coll. Stellar Chromospheres*). Linsky *et al.*, have observed the center of H and K lines.

2. *A-type supergiants*

Quantitative analyses, atmospherical motions and spectral variations. Buscombe (*B.A.A.S.*, **3**, 400) reports results of the analyses of the 4 supergiants HD 92207, 100262, 125835, and 161912. Wolf (*A.A.*, **10**, 383; **20**, 275) has made fine analyses of the A0Ib supergiant η Leo and the LMC supergiant A3Ia-O HD 33579. Stickland and Branch (*O.*, **92**, 9) constructed a curve of growth for ε Aur and compared it with α Per. The same star is studied by Castelli and Hack. Rosendhal and Wegner (*Ap.J.*, **162**, 547) and Rosendhal (*Ap.J.*, **160**, 627) have studied spectral variations and microturbulence in several A-type supergiants. Aydin (*A.A.*, **19**, 369) has studied the variations of microturbulence and radial velocities in 4 A-type supergiants. A correlation between microturbulence and radial velocity variations has been found for the Ia supergiants 6 Cas, 9 Per and ν Cep by Rosendhal and Wegner and for the Ib supergiant HD 39866 by Aydin. On 6 Cas, Abbasov *et al.* (*A.I.*, **4**, 81) have shown that the gravity determined from the profiles of hydrogen lines in its spectrum is two times less than that which corresponds to the mass and the radius of this star.

UV spectral line identification. Underhill *et al.* (*Ap.J.*, **171**, 63) have obtained UV scans for 6 supergiants in the spectral range B0I-A2I by means of the OAO II satellite. A broad absorption feature centered at λ 1720 and constant with spectral type has been found.

3. *High galactic latitude A-type stars*

Classification. Philip and Drilling (*B.O.T.y.T.*, **5**, 297) and Philip and Relyea (*B.O.T.y.T.*, **5**, 307) have made an objective prism survey of stars of spectral type A7 and earlier in the three areas 4 HLF 4; 3 HLF 4 and 1 HLF 3. Bond *et al.* (*P.A.S.P.*, **83**, 634) list RV and spectral types for over 100 A-type stars in the region of the south galactic pole. Rodgers (*Ap.J.*, **165**, 581) obtains spectra and UBV colours of 60 stars earlier than A7, $12 < V < 15$, close to the south galactic pole. Berger *et al.* have found 12 Si stars in a sample of 1970 high galactic latitude stars.

Quantitative analyses. Rodgers (*M.N.*, **157**, 171) derives T_{eff} and g and the Ca abundance by spectrophotometry of the continuum and lines for 18 high velocity stars. Przybylski (*M.N.*, **153**, 111) compares the horizontal branch star HD 106304 with α Lyr and finds that helium is normal and metals deficient by a factor of 7. Greenstein and Oke (*Ap.J.*, **159**, 985) studied the Population II star BD $+39°4926$. Kodaira and Tanaka (*P.A.S.J.*, **24**, 355) have found oxygen deficient as metals for HD 161817, 109995, and 86986, while the supergiant BD $+39°4926$ metal deficient. Stalio is studying a group of hot halo stars BD $-1°2858$, $+50°1631$, $+6°63$, HD 97589, 120086, BD + $+16°2114$.

4. *Ap and magnetic stars*

Discovery and classification. Bond (*P.A.S.P.*, **82**, 321) gives a list of Ap and Am stars discovered during an objective prism survey. Bertaud and Floquet have prepared a new catalogue of Ap and Am stars. A list of Ap stars which may have long periods is given by Preston (*P.A.S.P.*, **82**, 878). Cowley and Crawford (*P.A.S.P.*, **83**, 297) classify 22 stars, among them there are some new discovered Ap and Am stars. Dworetsky (*P.A.S.P.*, **84**, 254) gives the orbital elements of the double-lined binary star χ Lyr. Gulliver has found 18 new Ap stars; among them HD 51418 has the largest visual amplitude ($\Delta V = 0{\cdot}19$) of any Ap star.

Spectral variations and line identification. Winzer studied spectroscopic and UBV variations of several Ap stars. Line identification of two helium weak stars, HD 21699 and 36526 is tried by Brückner and Campbell respectively. Preston and Wolff (*Ap.J.*, **160**, 1071) have studied spectral, magnetic and photoelectric variations of HD 9996. Khokhlova (*A.Z.*, **48**, 534; **48**, 939) examines the variability characteristics of several magnetic stars. Bonsack (*P.A.S.P.*, **84**, 860) studies the line variations of 56 Ari. Bonsack *et al.* are studying the spectrum variations of 21 Com and line-blanketing variations of HD 125248. The variations of the magnetic field and line intensities of HD 24712 and HD 111133 are studied by Preston (*Ap.J.*, **175**, 465) and Wolffs (*Ap.J.*, **176**, 433) respectively. Floquet is studying the Ap spectroscopic variables HD 25354 and 216533. Faraggiana (*A.A.*, 1972) has finished the study of the spectral variations of 53 Cam. Megessier and Garnier (*Ap.L.*, **11**, 113) have carried out simultaneous photoelectric and spectrographic observations of the Ap star 108 Aqr. Aikman has observed all the mercury-manganese stars north of $\delta = -20$ from Osawa's list and the lists of the Cowleys and Jascheks and measured them for velocity in order to derive the spectroscopic binary frequency of this subgroup. Jaschek and Malaroda (*Nature*, **225**, 246) have identified lines of Au and U in the Ap star 73 Dra. Kuchowicz (*Nature*, **227**, 156) suggests the opportunity to look for lines of Pu in 73 Dra and other Ap stars. Bradi and Jaschek (*P.A.S.P.*, **82**, 847) looked for heavy elements in the spectra of 12 late Ap stars and found Os and Pr lines in five of them. Kodaira found the lines in Ap star HD 221568 tentatively identified as Pm II by Aller and Cowley (*Ap.J.*, **162**, L145) in HR 465. Havens and Heuvel (*A.A.*, **19**, 283) and Wolff and Morrison (*Ap.J.*, **175**, 473) discuss the possibility that the identification of the lines of Pm II in HR 465 may be due to chance and Aller and Cowley (*A.A.*, **19**, 286; *Ap.J.*, **175**, 477) defend their identification criteria. Preston (*Ap.J.*, **164**, L41) derives the isotopic abundances of Hg II in β CrB. Cowley and Aller (*Ap.L.*, **9**, 159) observed a variation in the contour of λ 3984 Hg II in HR 465 and suggest that this indicates a variation of the isotopic abundance of mercury. Jaschek and Brandi (*A.A.*, **20**, 233) have searched for and found nuclear fission elements with Z around 40 in HD 25354.

Magnetic fields. Observations of the magnetic field in Ap and Am stars have been carried out by Conti (*Ap.J.*, **160**, 1077), v.d.Heuvel (*A.A.*, **11**, 461), Wolffs (*Ap.J.*, **160**, 1049), Preston (*Ap.J.*, **160**, 1059; **164**, 309), Huchra (*Ap.J.*, **174**, 435), Gollnow (*O.*, **91**, 37), Wood (*B.A.A.S.*, **3**, 401). At Mauna Kea Observatory (Hawaii) an apparatus to measure Zeeman effect was placed in operation in early 1971. And investigations are in progress by Bonsack and Wolff (*Ap.J.*, **176**, 425) and, Bonsack *et al.* At Potsdam spectroscopic observations for deriving magnetic fields are under way by Scholz (*A.N.*, **292**, 279, 281), Hilderbrant *et al.*, Oetken and Orwert, and Barth. Potsdam astronomers do not agree with Conti's conclusion that the whole field is small, because they found marked differences for some lines between right and left-hand polarized light.

Continuous spectrum, effective temperature, gravity and quantitative analyses. Derivation of effective temperature of Ap stars is carried on by Megessier (*A.A.*, **10**, 332), Babu (*O.*, **91**, 115) and Glagolevskii (*A.Z.*, **48**, 942). Leckrone has studied Bp and Ap stars from OAO II observations. He finds that UV spectrum corresponds to the absorption line spectral type rather than to the *B-V* colour. A great number of quantitative analyses of Ap stars have been made by Evans and Elste (*A.A.*, **12**, 428), Leusin (*Comm. Special A.O.A.S. U.S.S.R.*, No. 5), Zverko (*B.A.I.* **21**, 56), Zimmerman *et al.* (*Ap.J.*, **161**, 179), Ross *et al.* (*Ap.J*, **161**, 189), Tomley *et al.* (*A.A.*, **9**, 380), Aller (*A.A.*, **6**, 67), Conti (*A.A.*, **7**, 213), Hardorp and Shore (*P.A.S.P.*, **83**, 605). Problems in connection with abundance anomalies in Ap stars are discussed by Nichols and Evans (*B.A.A.S.*, **2**, 333), Aller

(*A.A.*, **19**, 248), and Selvelli (*A.A.*, **20**, 325). Guthrie (*Ap.S.S.*, **8**, 172; **10**, 156; **13**, 168; **15**, 214), Engin, Stalio, Voigt, Floquet, Praderie *et al.*, and Vilhu (*A.A.S.F.*, **VI**, *Physica*, **394**) are also concentrating their efforts to the quantitative analyses of Ap stars. Durrant (*M.N.*, **147**, 59, 75) reviews the classification and atmospheric structures of Ap stars.

Rotation. A catalogue of rotational velocities for stars with peculiar spectrum Bp, Ap and Am stars has been prepared by Bernacca and Perionotto (*C.O.A.A.*, No. 250). Abt *et al.* (*Ap.J*, **175**, 779) measured the projected rotational velocities for all the bright northern Ap stars. Preston (*IAU Stellar Rotation Coll.*, 254) re-examined the period versus line-width relation for the periodic Ap stars. Study in connection with the rotation of Ap stars includes works by Cowleys (*P.A.S.P.*, **83**, 689) and Babu and Sinvhal (*B.A.C.* **26**, 297).

5. *Am stars*

Discovery and classification. Smith (*Ap.J.*, **161**, 1181) suggests that the ratio Sc II λ 4320/Y II λ 4309 can be used for detection of Am stars and by this ratio finds that in a sample of 70 bright mid-to-late A-type stars about 30% are Am, 10% Ap and 50% normal (*A.J.*, **76**, 896). The discovery of 5 Am stars in the extremely young Orion Ic association by Smith (*Ap.J.*, **175**, 765) suggests that the Am mechanism becomes operative in about 10^6 yr. Popper (*Ap.J.*, **169**, 549) obtains spectroscopic orbits for the metallic-line eclipsing binaries XY Cet, RR Lyn, MY Cyg. Smith (*P.A.S.P.*, **84**, 281) gives spectroscopic evidence that the Sc deficient F0 star HD 161227 is a double-lined binary. Gerbaldi (*C.R.*, **274**, 669) discusses the discrimination between Am and normal stars.

Quantitative analyses. Faraggiana and Meneret (*A.A.*, **12**, 258) have made a fine analysis of 15 Vul. Smith (*A.A.*, **11**, 325) makes a detailed analysis of 16 Am stars and several Fm stars. An inverse correlation of the Fe enhancement and deficient element anomalies with rotation is found. The theoretical interpretation is given by Watson (*A.A.*, **13**, 263), Smith (*A.A.*, **11**, 325), and Stickland and Whelan (*M.N.*, **155**, 11P.). Dworetsky (*B.A.A.S.*, **4**, 229) has carried out a quantitative analysis of the double-lined binaries HR 4072 and χ Lup. A review of the properties of the Am stars is given by Conti (*P.A.S.P.*, **82**, 781).

Blanketing. Ferrer and Jascheks (*A.A.*, **5**, 318) deduced blanketing correction for Am stars from UBVRI photometry and show that metallicity is related to the blanketing.

Pulsation. Breger (*Ap.J.*, **162**, 597) shows that Am stars are stable against pulsation while over 30% of normal stars in the same region of the HR diagram are variable. Bessell and Eggen (*P.A.S.P.*, **84**, 72) find an ultrashort period cepheid ($P = 0{\cdot}08$d) with a spectrum typical of an Am star. However, Breger (*P.A.S.P.*, **84**, 443) found no evidence of variability.

F, G, K STARS

1. *F stars*

Van 't Veer (*A.A.*, **11**, 197) studied the spectral type of the slowly revolving brightest component of the triple system 44i Boo. It is F5V. Zeinalov (*I.C.A.O.*, **41**, 298) has analyzed the spectra of two supergiants γ Cyg and ε Peg and found that the temperature and the microturbulent velocities are changed in their atmospheres. Kondo *et al.* (*Ap.J.*, **159**, 927) measured the energy curve in the range λ 2400–4000 and the equivalent widths of Mg II doublet at λ 2795 and 2802 for Canopus (F0 supergiant). Doroshenko (*A.Z.*, **49**, 494) has shown that the energy distribution in the spectrum of the star BD $+60°2522$ can be represented as a sum of the energy distribution of O5 and F5Ib stars.

Chemical composition. Powell (*R.O.B.*, No. 167; *M.N.*, **148**, 477) determined the chemical composition of 12 late F dwarfs by differential curve-of-growth analysis. The same method was applied for δ Sct by Dickens *et al.* (*M.N.*, **153**, 1) and for α CMi by Griffin (*M.N.*, **155**, 139). δ Sct shows a metal abundance greater than the Sun's and α CMi has element abundances similar to those of the Sun. Branch and Bell (*M.N.*, **151**, 289) concluded that the ultraviolet deficiency of the F8 subgiant HR 244 is caused primarily by a low gravity from the curve-of-growth analysis. Anderson and Kraft (*Ap.J.*, **167**, 119) tried the abundance analysis of the long-period Population II Cepheid

TW Cap. Kodaira *et al.* (*Ap.J.*, **159**, 485) have made abundance analysis of +39°4926. The He/H ratio is temperature-dependent. The ratio of C/H and of O/H is near that in the Sun. The metal abundances average 1% of their solar values, differ from element to element, and show an excessively large odd-even alternation. Schmidt (*Ap.J.*, **170**, 109) carried out the coarse and detailed analyses of the iron spectra for 4 classical Cepheids, η Aql, U Sgr, S Nor, and Y Oph. The 4 Cepheids analyzed have identical Fe abundances. Osmer (*Ap.J.S.*, No. 206) carried out a detailed study of 25 F supergiants by means of model-atmosphere techniques. In connection with the abundance analysis, it is very important to check the validity of the revised *gf*-scale and to establish a standard in differential method. Yamashita's (*P.A.S.J.*, **24**, 49) work on this problem should be remarked.

2. *G stars*

Most of spectroscopic works on G type stars seem to concentrate to the problems of chemical abundance lately. Powell is carrying out a curve-of-growth analysis of sub-luminous, UV deficient G dwarf α Men. Boyarchuk and Vozhansky (*I.C.A.O.*, **41**, 342) have investigated the chemical composition of 4 K type stars, 70 Oph, ε Peg, GI Cyg A, and ξ Cyg. They found Sr, Y and Ba are more abundant by the factor 3 than that in the Sun.

The situation is particularily confusing for metal-rich stars. Spinrad and Williams agree on the existence of a rather well defined group of 'super-metal-rich' stars. Spectroscopic investigations of a few of these objects have lead to disconcerting results. Two stars, HR 72 studied by Spinrad and Luebke (*Ap.J.*, **160**, 141) and Branch and Bell (*M.N.*, **153**, 57) and 31 Aql studied by Hearnshaw (*Ap.J.*, **168**, 109; *M.R.A.S.*, **77**, 55) as well as by Fernandez (*R.M.*, **63**, 76) and Rego (*U.B.*, **55**, 3) support this concept. But 5 other SMR studied by Strom *et al.* do not show any clear overabundance of iron. Cayrel and coworkers have extensively restudied 2 of Strom's stars, μ Leo and ϕ Aur (Blanc-Vaziaga, *Ap.J.*, 1973) and HD 6497 (Pasinetti, *17 Col. IAU*). These objects seem to have no super-metallicity. Clearly the problem deserves more study.

A few metal-poor stars have been studied: HR 646 and HR 860 (Spites), 15 Peg (Thomas, thesis), α Crv, HR 3018 (Yoshioka, Da Silva), HD 91324 (Da Silva) and o Vir (Willians, *M.N.*, **155**, 17p). Nitrogen turns out to be an interesting element in metal poor stars. A low value of the nitrogen/iron ratio was first detected in the metal poor star ν Ind by Harmer and Pagel (*Nature*, **225**, 349) and confirmed by Bell (*M.N.*, **150**, 15). According to Bond (*Ap.J.*, **160**, 1127), a high velocity G-star, HD 204613 is not extremely weak-lined and in fact appears to show a great enhancement of Sr II and CH.

3. *K stars*

Fine analysis of some main sequence K type stars shows that for KV stars a fairly accurate determination of the chemical abundance is possible although the atmospheric structure cannot be presented in a simple manner. KV stars with equal chemical composition may have different chromospheric activity. These conclusions have been obtained by Strohbach (*A.A.*, **6**, 385). Strom *et al.* (*A.A.*, **12**, 177) tried a model atmosphere analysis of 5 apparantly super-metal-rich K giants. The results suggest that stars selected by Spinrad and Taylor (*Ap.J.*, **157**, 1279) as SMR are a mixed group having one or more of the following characteristics (a) higher turbulence, (b) enhanced CO and/or CN band strengths, (c) a slight increase in metal content. An abundance analysis of the late type supergiant ε Peg (K2Ib) by Warren and Peat (*A.A.*, **17**, 450) suggests the abundance of the light elements ($A \lesssim 62$) could have resulted from explosive carbon burning in the pregenitor material occurring at a lower temperature than that in the solar pregenitor material. Wolffram (*A.A.*, **17**, 17) analyzed the metal-poor K giant HD 122563. An analysis of the $C^{12}O$ and $C^{13}O$ rotational lines in α Boo by Greene (*Ap.J.*, **161**, 365) shows the O/C ratio is about 2·5 and the C/H ratio is about 1/3 of the solar value and the C^{12}/C^{13} ratio exceeds 10. Catchpole (*M.N.*, **154**, 15p) obtained Li abundance for the Sco-Cen star HD 113703 ft (K0Ve) higher than the solar value by 1·4 dex. It is interesting to note that Fosbury (*M.N.*, **155**, 7p) identified a feature in the wing of the K-line in α Boo with an emission line of Nd II.

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4. *F–G, G–K, F–G–K stars etc.*

The spectroscopic study through F-G, G-K, F-G-K etc. may present somewhat different and interesting results which could not be obtained by simply pursuing a single spectral type. Some comprehensive works will be introduced in order to help our understanding of the spectral sequence.

F–G stars. Chaffee *et al.* (*Ap.J.*, **166**, 593) made a detailed analysis of 6 F and G dwarfs in the Pleiades and 14 in the Hyades. It was shown the Fe/H ratio in the Hyades is 50% higher than that in the Pleiades.

G–K stars. Pagel (*Q.J.R.A.S.*, **11**, 172) reviews present knowledge of the atmospheric compositions of normal stars of late type G–K and their bearing on theories of nucleosynthesis and the evolution of the Galaxy. Fine analysis of 5 stars of the γ Leo group has been carried out by Zielke (*A.A.*, **6**, 206). The technique developed by Spinrad and Taylor for obtaining metal abundances of late-type stars was applied by Taylor (*Ap.J.S.*, No. 186) to field G and K dwarfs in the solar neighborhood. Super-metal-rich dwarfs are found in the solar neighborhood and the He abundance ranges from 0 to 50% by weight for some stars. Warren is investigating heavy element abundance in Southern G and K supergiants. He has completed a model-atmosphere curve-of-growth analysis for the supergiant HR 5171. There appears to be no significant difference from solar abundances. Williams (*M.N.*, **155**, 17p) analyzed o Vir using model atmospheres. The results show o Vir is generally metal-poor, but overabundant in heavy metals. Unlike the Ba II and CH stars, however, it appears to be anomalously rich in O. Miscellaneous works on GK stars include Strittmatter and Norris' (*A.A.*, **11**, 477) study on rotational velocities obtained from spectroscopic method for G and K giants in the Hyades Moving Group, Koelbloed's (*A.A.*, **16**, 230) study on excitation temperatures for Fe I and Ti I by curves of growth for late G and K type giants, and Griffin's (*M.N.*, **147**, 303) measurements of the resonance line of Sc I λ 6305 for some 300 GK stars by the Cambridge technique of narrow-band spectrophotometry. Taylor *et al.* (*Ap.J.*, **173**, 619) show by the scanner abundance study that the metallicities of some of strong-CN GK stars compare favourable with the most extreme super-metal-rich stars. A list of 146 stars with strong CN is given by Schmitt (*Ap.J.*, **163**, 75).

F–G–K stars etc. Strobel *et al.* (*A.A.*, **7**, 408) review critically the values already existing in the literature of the abundance of sodium with respect to iron in 128 F, G and K dwarf and giant stars. Wilson (*Ap.J.*, **160**, 225) measured fluxes in the centers of the H and K lines for 65 Hyades stars between F4 and K5. Analysis of these measures shows that the radiation in the chromospheric H and K emission lines increases by a factor of 2 between B-V = 0·45 and 1·25. Schmidt (*Ap.J.*, **174**, 595) observed Hα profiles for 28 Cepheids and non-variable F, G, and K stars of all luminosity classes to find effective temperatures. Wilson and Woolley (*M.N.*, **148**, 463) found a very clear correlation between the Ca-emission intensities and the eccentricities and inclinations of the orbit from G–K–M dwarfs survey. This reinforces the view that main-sequence stars with strong Ca reversals are young, and have near circular orbits with low inclinations to the galactic plane. Smoliński is studying coudé spectra obtained at Victoria for a sample of 60 bright giants and supergiants of types F, G, and K.

Chaffee (*A.A.*, **4**, 291) obtained microturbulent velocities for 23 main-sequence stars in the spectral range from A2 to G0 from a curve-of-growth analysis. Stars of unusual composition are found by Stroms (*A.A.*, **14**, 111) in the course of a spectroscopic survey of the red giant and asymptotic giant branch stars of the metal-weak globular clusters M92 and 22. Tarafdar and Vardya (*Ap.J.*, **178**) have shown the discrepancy between observed and calculated ultraviolet fluxes of A to K stars can be largely alleviated between λ 1376–2400, if the A-X band of CO and bound-free transitions of Al I are incorporated in the model calculations.

M, S, C-TYPE STARS

M, S and C-type stars which belong to the late-type in the spectral classification are interesting objects with complexity in their relations with each other. One of interesting problems is their

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branching, because we find such stars which are intermediate in their spectroscopic characteristics between S and C. Those stars SC and CS may need more observations in order to make the clear understanding of their positions in spectral classes. Another problem is the model atmosphere approach, because it is still difficult to give any exact idea upon the physical data of their atmospheres. A monograph 'Interpretation of Spectra and Atmospheric Structure in Cool Stars' (1970) by Fujita gives summary on the works carried out by him and his colleagues and another one 'Carbon Stars' (1971) by Alksne and Ikaunieks contains the results of the investigation of the cool carbon stars in general and some works carried out in Riga.

1. *M stars*

Wyckoff and Wehinger (*Ap.J.*, **164**, 383) classified near-infrared (λ 7000–8900) spectra of 7 cool M-type long period variables. From an infrared objective-prism survey carried out along the Southern Milky Way, Albers (*Ap.J.*, **176**, 623) obtained a catalogue of 170 M stars showing a CN absorption feature at λ 7900. Doan (*A.A.*, **8**, 307) studied about 20 spectra of CH Cyg (M6) with a moderate dispersion since the outburst of 1967. Spectral variations of the same star during the period 1967 to 1970 are studied by Faraggiana and Hack (*A.A.*, **15**, 55) using high dispersion spectrograms. Keller *et al.* (*A.A.*, **4**, 415) derived the rotational temperature of a TiO band in the spectrum of R Hya (gM7e). The absolute visual magnitude of $-5{\cdot}3$ was estimated by Keenan (*Ap.J.*, **162**, 199) for the supergiant component (M3Iab) of CPD-56°3586. Orlov *et al.* (*S.A.J.*, **14**, 690) derived the abundances of several metals in the atmospheres of 4 supergiants of types M1–M5 from a curve-of-growth analysis. Compared with the Sun V and Sc are overabundant and Ni is deficient. Wallerstein (*Ap.J.*, **169**, 195) reports spectroscopic observations of VY CMa during 1969–1971. New identifications include Ru I, TiO, and VO band heads.

2. *S stars*

Perry and Beebe (*Ap.J.*, **160**, 619) determined the isotopic ratio of Zr in the spectrum of a long-period variable S star, R Cyg, by matching computed and observed profiles of the $\gamma_2$0-0 band of ZrO. Fractional abundances of Zr^{90}, Zr^{91}, Zr^{92}, Zr^{93}, Zr^{94}, and Zr^{96} are close to the abundances expected from the production by the *s*-process after extensive neutron exposure. Wyckoff and Wehinger (*Ap.J.*, **172**, 117) discuss the unidentified band observed in the near-infrared minimum-light spectrum of S Lyr. Evidence is presented by Davis (*Ap.J.*, **167**, 327) for Pm I and Pm II in S-type stars V Cnc and T Sgr. Tsuji (*P.A.S.J.*, **23**, 275) analyzed high dispersion spectra of Se-type Mira variables, R And and R Cyg, and discussed atmospheric structure, mass loss and chemical composition of these stars.

3. *C stars*

Spectrum behaviour. A brightening of the ultraviolet (below λ 4000) spectrum of the carbon star HD 59643 was observed in 1970 Feb. by Green and Wing (*Ap.J.*, **163**, 309). Richer (*Ap.J.*, **172**, L63) observed three carbon stars exhibiting composite spectra. Fujita (*P.J.A.*, **46**, 295) found forbidden [C I] 8727 line in some carbon stars. The intensity variation of this line in the spectral sequence of carbon stars may be of some interests in connection with dissociative equilibrium of carbon compounds. Utsumi searched for Tc I lines in the spectra of 16 C stars. He suggests that Tc is present only in stars with large overabundance of heavy metals. Utsumi and Yamashita (*P.A.S.J.*, **23**, 437) estimate absolute magnitude of C stars HD 182040, T Lyr and V Aql from the equivalent widths of D lines. Fay and Johnson (*P.A.S.P.*, **84**, 284) searched for rotational lines of the (0, 0) and (1, 1) bands of C_2^- in the spectrum of the CH star HD 201626. Good coincidences are obtained for the stellar and laboratory wavelengths. However, the identification of C_2^- must still be considered uncertain because of a complexity of the spectrum.

Classification. Richer (*Ap.J.*, **167**, 521) employed near-infrared (λ 7500–8900) spectrograms of moderate dispersion to establish a new two-dimensional classification scheme for carbon stars

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which involves temperature and luminosity. Fujita (*P.J.A.*, **47**, 615) examined six absorption features including C_2, CN and Na I from spectroscopic scanning. It seems plausible that $C_2(0, 0)$ and CN(6, 1) of Red System are good indicator of the spectral type of carbon stars.

Abundance. Utsumi (*P.A.S.J.*, **22**, 93) finds large over-abundance of *s*-process elements from the curve-of-growth analysis of 22 carbon stars. Quercis (*A.A.*, **9**, 1) have constructed absolute molecular curves-of-growth for the carbon star UU Aur from $C^{12}N^{14}$ Red System and $C^{12}C^{12}$ Phillips System. The excess of N^{14} and the lack of appreciable C^{13} in this star were obtained. Thompson *et al.* (*Ap.J.*, **163**, 533) have measured equivalent widths of C_2 and CO infrared (1–4 microns) absorption bands in 4 carbon stars (W Ori, X Cnc, U Hya, and 19 Psc). A comparison of the observed abundances with the best available theoretical models indicates agreement with the predicted CNO bi-cycle H/C ratio. Green *et al.* try an abundance analysis of the carbon star HD 156074. The CNO abundances are abnormal with C^{13} enhanced, N^{14} enhanced and O deficient. These abundances combined with the fact that the heavy *s*-process elements and Li are not enhanced are very difficult to explain by the CNO bi-cycle. Thompson (*Ap.J.*, **172**, 391) argues that carbon stars cannot be the result of mixing CNO bi-cycle products to the surface, because insufficient material is processed in the stellar interior to affect the C^{12}/O^{16} ratio significantly at the surface of the star. The explanation by the CNO bi-cycle still seems to require some time to be settled.

C^{12}/C^{13} abundance ratio. This is one of interesting problems to make clear through the whole spectral range of carbon stars. Fujita *et al.* are estimating C^{12}/C^{13} ratio from the relative shift of the empirical pseudo-curves of growth for $C^{12}N$ and $C^{13}N$ in the spectral range λ 7700–8100 of early and late carbon stars.

Fay (*Ap.J.*, **168**, 99) determined C^{12}/C^{13} ratio from the (1, 0) and (0, 2) bands of the CN Red System which ranges from 2 to 5 for RY Dra and Y CVn, but is greater than 20 for 19 Psc.

Climenhaga and his colleagues are studying the C^{12}/C^{13} abundance ratio from C_2 λ 6200 and CN infrared bands. Though it is not a real carbon star, a red giant in the globular cluster ω Cen observed by Dickens (*M.N.*, **159**, 7p) is a very interesting object. Dickens indicates that the C^{13} content is relatively high from the absorption features of C_2 around λ 4737.

4. *SC stars*

Keenan (*M.N.*, **153**, 1p) describes the spectrum of Welch's red variable in Cru. It may be a member of the SC class. A search has been carried out by Catchpole and Feast (*M.N.*, **154**, 197) for stars similar to the SC type star UY Cen, and 12 are listed in a table. The 6 stars newly assigned to the group were selected for observation on the basis of an objective prism survey by Henize. The spectroscopic characteristics defining the group are discussed and the differences from CS stars like R CMi are noted. Catchpole has extended his work on line identification in the SC type star UY Cen into the infrared and has also observed other SC stars in the infrared.

5. *K-M stars*

Gahm (*A.A.*, **4**, 268) searched for classification criteria in spectra of K and M type stars. Gahm and Hultqvist (*A.A.*, **16**, 329) observed spectral characteristics of 52 luminous stars of spectral class K0 to M7. D line profiles, intensity of Hα and the Li abundances are obtained.

6. *F-M stars*

Chériguene (*A.A.*, **13**, 447) presents new system of stellar lines for the determination of radial velocities of late type stars F6-M2.

7. *M-C stars*

Barbier (*A.A.S.*, **2**, 201) lists 101 new M–C and emission line stars covered on objective prism plates. Herbig and Zappala (*Ap.J.*, **162**, L15) obtained coudé spectrograms in the λ 7500–8700

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region of the infrared sources NML Cyg and IRC + 10216. NML Cyg appears to be a normal M6III, while IRC + 10216 is a late-type carbon star. Chauville *et al.* (*A.A.S.*, **2**, 181) identified atomic transition in M stars from the survey of M and C stars (4000 and 9000 cm^{-1}). Wing and Spinrad (*Ap.J.*, **159**, 973) identified CN red bands in the region 1·1–2·5 microns of M and C stars. Photoelectric scans of α Ori (M supergiant), and the carbon stars 19 Psc, W Ori, and DS Peg in the spectral region λ 6000–11000 by Fay and Honeycutt (*A.J.*, **77**, 29) show the dominant spectral features due to C_2, CN, and TiO.

8. *M-S-C stars*

Wyckoff (*Ap.J.*, **162**, 203) examined low-dispersion near-infrared (λ 7000–8900) slit spectra of M, S, and C stars. Intensities of various absorption features are discussed in terms of spectral types, light variations, and abundances. Boesgaard (*Ap.J.*, **161**, 163) obtained the Ti/Zr ratio by a curve-of-growth technique for 36 K-M stars, 5 Ba II stars, 6 M–S stars, and 9 S stars. The Ti/Zr ratio for the K and M giants is similar to the solar value. In the Ba II and S stars, the average value of this is about 6 times less. The average for the M–S stars is intermediate between the normal stars and the Ba II and S stars.

9. *Theoretical aspects*

Model atmospheres. Goon and Auman (*Ap.J.*, **161**, 533) calculated the projected densities of the molecular constituents of K and M stars by using model atmospheres. Discussions on the C and O abundances and opacities are given. Alexander and Johnson (*Ap.J.*, **176**, 629) calculated model atmospheres for cool giant stars having a wide range of chemical composition in the ranges of T_{eff} from 2500 to 4000K and $\log g = 1{\cdot}0$ to $-1{\cdot}0$. It is found from the calculations of the model atmospheres of cool stars by Swamy (*Ap.J.*, **162**, 259) that the extinction due to graphite particles is appreciable compared with the absorption due to other sources. Yamashita (*P.A.S.J.*, **22**, 239) suggests that even in the coarse analysis of curve-of-growth in atmospheres of late-type stars, calculations based on model atmospheres should be employed.

Opacity. Some properties of stellar opacities at relatively low temperatures are studied by Tsuji (*P.A.S.J.*, **23**, 553). Johnson is investigating the CO infrared opacity (1·5–5·0μ) in stellar atmospheres. For model atmospheres with $T_{eff} = 3000$–5000K, CO lowers the boundary temperature by amounts up to 1000K and usually backwarms the photosphere slightly.

Molecular abundance. Tsuji (1972) solved chemical equilibria of 36 elements for the physical conditions of cool stellar atmospheres. It is found that the molecules formed and the degree of molecular association, that is the fraction of atoms locked in molecules, are well correlated with the position of each element in the periodic table.

WHITE DWARFS

Spectroscopic behaviour. Greenstein (*Ap.J.*, **162**, L55) gives spectroscopic data on 18 newly observed white dwarfs. Very unusual spectra of several show molecular bands and lines of C. Greenstein (*Ap.J.*, **173**, 377) obtained acceleration, pressure broadening and shifts in Ca II, Fe I spectrum from the study of Van Maanen 2. Bolan *et al.* (*A.A.*, **16**, 431) determined the energy distribution in the λ 3500 to 6600 region of the spectrum of Van Maanen 2. Some line profiles are obtained. Burbidge and Strittmatter (*Ap.J.*, **170**, L39) report a He emission-line star G61-29. It is the first time that He alone has been discovered in emission. Wegner (*Ap.J.*, **172**, 451) observed 5 cool white dwarfs. The results of its analysis show that the atmospheres of the cool white dwarfs are nearly pure He. The metal and hydrogen abundances are of the orders of 10^{-9} and 10^{-4} by number, respectively.

Model atmosphere approach. Bues (*A.A.*, **7**, 91) computed flux constant model atmospheres in order to explain the spectra of helium-rich white dwarfs, spectral type DB. Wegner (*P.A.S.A.*, **2**, 30) computed model atmospheres consistent with T_{eff}, g and assumed chemical composition. In all the models He^- is the dominant opacity source. Radiative models were first constructed using Lucy's

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temperature correction method. Wehrse (*A.A.*, **19**, 453) constructed model atmospheres for cool hydrogen-rich white dwarfs. The blanketing effect of more than 2380 atomic and molecular lines has been taken into account in a statistical approach.

PECULIAR STARS

A catalog of 5326 early-type emission-line stars is presented by Wackerling (*M.R.A.S.*, **73**, 153) and the second catalogue containing 323 emission-line stars of the Orion population is given by Herbig and Rao (*Ap.J.*, **174**, 401). A list of 101 new M, C and emission-line stars discovered on objective-prism plates is given by Barbier (*A.A.*, **2**, 201).

Model atmosphere techniques have been used for an analysis of the spectrum of the Si star HD 34452 by Tomley *et al.* (*A.A.*, **9**, 380). It appears that almost all the peculiar stars of types B, A and F, including the metallic line stars, have an excess of iron. Fehrenbach observed the star S22 of the Large Magellanic Cloud showing emission lines of Fe II and [Fe II].

Identifications and intensities are given by FitzGerald and Houk (*Ap.J.*, **159**, 963) for 130 emission lines between λ 3130 and 5030 measured on fifteen spectrograms of a peculiar emission object V1016 Cyg (M Hα 328–116). The line intensities and ratio do not give a completely consistent picture; however, they indicate that the temperature of the emitting regions increased from 1965 through 1967, and that the density decreased. The object V1016 Cyg may well be a planetary nebula in the early stages of its evolution. Wallerstein (*Ap.J.*, **166**, 725) analyzed emission lines in W Cep (K0pe Ia) to yield an electron temperature of 5000–6000 K and an electron density of $2\text{–}4 \cdot 10^9$ cm^{-3}. Much of the infrared excess can be explained by free-free emission from an envelope of radius 15 AU. Strom *et al.* (*Ap.J.*, **193**, 353) carried out a quantitative spectrophotometric study of the Herbig Ae and Be stars associated with nebulosity. The majority have surface gravities appropriate to pre-main-sequence stars. This evidence, along with their similarity to T-Tau-like stars and the fact that all these stars appear to be surrounded by circumstellar dust, place them among the youngest known stellar objects. Spites report that spectra of stars suspected of metal deficiency, were obtained at 2 Å mm^{-1}, by means of a spectrograph associated with the Lallemand-Duchesne electronic camera, allowing good resolution and good photometry, due to the linear response of electronic camera.

BINARY STARS

VV Cep system. According to Wright, recent work on VV Cep system has concentrated on the Hα line which shows a broad emission line produced by the rotating envelope, with the normal M-type absorption near the center. When the effect of the M star has been removed by subtracting this absorption, and the results rectified to the continuum of the emission line, a complex mixture of emission and absorption lines remains. This complex has been analyzed for about 70 spectrograms taken between 1956 and 1972 and the system's physical image is given. With regard to the secondary eclipse, there is spectroscopic evidence, both from the infrared O I lines and from studies of Hα that mid-eclipse occurred during the summer of 1964. This system is probably one of the most complex that we know, but it is bright enough to observe at high dispersion. When the analysis is completed it is hoped that we shall know more about mass motions in and around these giant binary systems (Hutchings and Wright, *M.N.*, **155**, 203).

Other works carried out on the VV Cep groups include the spectral features in the far ultraviolet of HR 2902 (M2 ep Iab + B2(V)) by Jaschek and Brandi (*A.A.*, **16**, 115), study of new VV Cep stars by Barbier (*A.A.*, **14**, 1971).

ζ Aur stars. Wright reports the 1971–1972 program for observing the ζ Aur stars. The Dominion Astrophysical Observatory was asked by IAU Commission 42 to coordinate the observing programs and the preliminary results are now available on 32 Cyg, ζ Aur, and 31 Cyg.

Kitamura and his associates obtained quite a number of coudé spectrograms in blue and Hα-regions of 31 Cyg, 32 Cyg and ζ Aur in their 1971–1972 eclipses at the Okayama Astrophysical

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Observatory. They are now engaging in analyzing work of these spectrograms for radial velocities and chromospheric lines.

Other binaries. Buscombe and Barkstrom (*M.N.*, **152**, 37) studied the composite spectra of γ Cir (B III? + F8V?) and interpreted the pair as an optical double of 1″ separation with counter-clockwise relative motion. Powell and French (*Ap.L.*, **6**, 131) discussed the position of α Cen A and α Cen B in the two-colour diagram in relation to their chemical composition. Both stars have a composition similar to that of the Sun, but α Cen B has been found to have an ultraviolet deficiency relative to the Hyades. A similar anomaly in the case of δ Pav has been previously explained by the existence of a large microturbulent velocity. However, results of a differential curve-of-growth analysis show α Cen B to have a microturbulent velocity slightly less than that of the Sun. Another paper dealt with α Cen is by Norris (*Ap.J.S.*, No. 197, **23**, 235). He obtained spectra (λ 3800–6700) and continuum measures (λ 3400–5600) of α Cen during the years 1967–1969. These have been used to determine the variations of several observational parameters: hydrogen line profiles, helium and metallic line strengths, continuum magnitudes and colours, and radial velocities.

VARIABLE STARS

1. *Variable stars*

Van Paradijs (*A.A.*, **11**, 299) analyzed nine spectrograms of δ Cep by curve-of-growth methods. By the differential curve-of-growth analysis Kobayashi and Takeuchi (*S.R.T.U.*, **54**, 33) found the variation in atmospheric parameters is rather mild and the Fe/H in δ Cep may be about 4 times larger than that of the Sun. Schmidt (*Ap.J.*, **162**, 871) examined the Hα profile for a number of Cepheids and compared it with the computed profiles to determine the temperature variations.

Spectra of some long-period variable stars have been studied by some people. Maehara (*P.A.S.J.*, **22**, 119) identified two lines at λ 4138 and 4178 which appear in the spectra of χ Cyg and o Cet with the fluorescence lines of SiH molecules excited by Hδ emission. Maehara (*P.A.S.J.*, **23**, 313) carried out spectral analyses of 7 Mira-type long-period variable stars and discussed the variation of physical conditions in the atmosphere associated with the stellar pulsation. From spectra of χ Cyg and o Cet Maehara (*P.A.S.J.*, **23**, 503) found differential radial velocities and discussed their dynamical models. Nussbaumer and Swings (*Ap.J.*, **172**, 121) discussed the behaviour of the emission-line intensities of Mn I and [Mn I] in the spectra of χ Cyg in terms of fluorescence. Wilson (*A.A.*, **17**, 354) shows that a statistical equilibrium analysis of the fluorescent emission of $\lambda\lambda$ 4202, 4308 of Fe I in the long-period variables indicates that coincidence mechanism first proposed by Thackeray is consistent with the observed intensities.

Boyarchuk (*I.C.A.O.*, **41**, 264) has shown that the chemical compositions of the symbiotic stars AG Dra, Z And, AX Per, CI Cyg, BF Cyg and MHα 328–116 do not differ from that of the planetary nebula NGC 7027. Zaitseva and Kolotilov (*A.Zr.*, No. 699) have discovered the Hα emission in the spectra of VX Cas, BH Cep, BO Cep, and SV Cep. They found that the Hα emissions show the variations in the spectra of AB Aur, RY Tau, UX Ori, BN Ori and VX Cas. Andrillat (*Trieste Colloq.*, 1972) presented the spectrum of the variable HBV 475. She concludes this star seems to be a symbiotic star and evolving to a planetary nebula.

Gershberg (*A.*, **6**, 191) has determined intensities of emission lines in quiet state spectra of two flare stars AD Leo and EV Lac. Comparison of these data with solar ones leads to conclusion that the density of stellar chromospheres is ten times larger than that of solar chromosphere, and that flux density of non-radiative energy from stellar underphotospheric layers is $1 \sim 2$ orders of magnitudes higher than at the Sun. Gershberg and Shakhovskaya (*A.Z.*, **48**, 934) report the spectra obtained during a strong flare of AD Leo on 1970 Mar. 2 and have found fast variations of emission line profiles in spectra of the AD Leo strong flares. Gershberg (*I.C.A.O.*, **45**) has found strong Ca II emission in spectra of flare star YZ CMi during some hours after the photometric phase of the large flare.

Wood (*B.A.A.S.*, **2**, 226) reports spectrum variability in β Car. Gahm (*Ap.J.*, **160**, 117) presents a catalogue of emission and absorption lines and line intensities of RW Aur covering the region

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λ 3250–4900. Alexander *et al.* (*M.N.*, **158**, 305) present the results of an intensive spectroscopic and photometric study of the R CrB type variable RY Sgr during the period of 1967–70. Ishikawa (*P.A.S.J.*, **25**, 111) tried a curve-of-growth analysis of the spectra of δ Del in blue region and obtained the abundances of 20 elements.

2. *Nova and Supernova*

Nova. Kodaira (*P.A.S.J.*, **22**, 447) observed the energy distribution of Nova Ser 1970 around its light maximum. The distribution was found to be similar to that of F-type supergiants, when the principal emission spectra were still absent. Andrillat collaborated by Houziaux and Fehrenbach, has investigated spectra of two novae, Del 67 and Cep 71 mainly in the infrared region. Profiles of He I λ 7065, O I λ 7772 and 8446, and [O II] λ 7319–7330 have been obtained and their variations discussed. Study of Nova Cep 71 has been carried out in the spectral region λ 3100–8750. Literatures are given as follows:

Andrillat and Houziaux (*Ap.S.S.*, **6**, 36), Nebular and coronal lines in the infrared spectra of Nova Del 1967; (*Ap.S.S.*, **9**, 410), Evolution of spectra of Nova Del 1967 in the infrared region; (*Ap.S.S.*, **12**, 184), Observation of nebular spectra in the spectral region λ 5600–8800. Andrillat and Fehrenbach (*C.R.*, **275**, 572), Observation of Nova Cep 1971; (*L'A.*, **85**, 409), Nova Cep 1971; (*C.R.*, **274**, 1179), Evolution of the spectra of Nova Cep 1971.

Friedjung (*A.A.*, **14**, 246) studied line profiles of some spectra of Nova Her 1963. Friedjung and Malakpur (*A.A.*, **18**, 310) report on the metallic absorption lines of Nova Del before the December 1971 maximum. Friedjung (*A.A.*, **14**, 440) discussed the excitation and ionization of the parts of a nova envelope producing the principal absorption system. Antipova (*S.A.J.*, **15**, 15, 225) discusses the hydrogen absorption lines in the envelope of Nova Her 1934.

Supernova. Mustel (*S.A.J.*, **15**, 1) presented line identifications to interpret the type-I supernova spectra. In next paper (*S.A.J.*, **15**, 527) Mustel discussed the problem of the temperature of type I supernova envelopes near maximum light more fully than in the previous paper.

UV AND IR STELLAR SPECTRA

1. *UV stellar spectra*

Mainly identification works have been carried on UV spectra of stars. Among them, Smith (*Ap.J.*, **160**, 595) identified 102 multiplets of stellar and interstellar origin in the spectrum of ζ Pup (O5f) in the region from λ 920 to 1360. Kondo (*Ap.J.*, **171**, 605) obtained the UV spectrum (λ 2700–4000) of α Boo. Carruthers (*Ap.J.*, **166**, 349) obtained far-ultraviolet (λ 1000–1500) spectra for several early type stars in Per. Moos and Rottman (*Ap.J.*, **174**, L73) obtained a far-ultraviolet (λ 1200–1900) spectrum of α Boo showing chromospheric emission features. Lyman α and O I λ 1304 are clearly identified. Smith (*Ap.J.*, **172**, 129) obtained a spectrum of ζ Ori (a binary of O0·5Ib and B3) in the region λ 922–1453. Line identifications are given. Fifteen multiplets of subordinate lines are reliably identified, indicating an approximate range of excitation from 0 to 50 eV. Several lines show P Cyg-type profiles presumably arising in a circumstellar envelope. Several interstellar lines are definitely identified. Gurzadyan and Chanesyan (*A.A.*, **20**, 321) detected and identified more than ten ultraviolet absorption lines and bands in the UV spectrograms of Vega covering λ 2000–3800. A rocket UV spectrum of γ Cas (B0·5IVpe) (λ 1060–2130) was studied by Bohlin (*Ap.J.*, **162**, 571). He obtained an average density of interstellar H I and upper limit of H_2. Possible interstellar lines of C II, N I, and Si II are discussed.

2. *IR stellar spectra*

Identification of molecular lines seems one of main works in IR spectra. Fertel (*Ap.J.*, **159**, L7) gave a tentative identification of SiO in the IR (1·5–2·3 μ) spectra of cool stars. However, Wing

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and Price (*Ap.J.*, **162**, L73) report his identification of SiO is almost incorrect, since no account was taken of the extensive absorption by the red CN system. Then Fertel (*Ap.J.*, **162**, L75) replies some infrared absorption features recently identified with SiO do not in general coincide with features attributable to CN. It needs further observation to settle this problem. In connection with SiO, it is interesting to note that Cudaback *et al.* (*Ap.J.*, **166**, L49) identified the first-overtone vibration-rotation band of SiO in the 4μ spectrum of α Ori. Beer *et al.* (*Ap.J.*, **172**, 89) present the IR (2·9–3·8 μ) spectrum of α Ori by the use of the Fourier spectrometer at a resolving power of 10000. The vibration-rotation lines of OH are studied and a temperature of 4100K and OH abundance of $1{\cdot}2{\cdot}10^{20}$ molecules cm^{-2} are obtained. Strong water absorption at 1·9 μ was found by Frogel (*Ap.J.*, **162**, L5) in the long-period Mira-type variables that have water emission at 1·35 cm. The variation in the strengths of these two features is anticorrelated with one another. Thompson and Schnopper (*Ap.J.*, **160**, L97) give the identification of the (2,4) and (3,5) bands of the CN red system in the spectra of carbon stars W Ori, 19 Psc, U Hya, and X Cnc (2–2·5 μ). Low *et al.* (*Ap.J.*, **160**, 531) carried out photometric observations from 0·36 to 22 μ and spectroscopic observations from 2500 to 7000 cm^{-1} of infrared stars, Becklin object, HD 45677, R Mon, T Tau, NML Cyg, and VY CMa.

LI-ABUNDANCE

Boesgaard has attacked the problem of Li-abundance in stars. In *Ap.J.*, **159**, 727 she determined the Li isotope ratio for δ Sge (M2 Ib–II) from the shift of the center of gravity of the Li doublet at λ 6707 and found the Li^6 content to be $12 \pm 6\%$ of the total Li. Then, in *Ap.J.*, **161**, 1003, Boesgaard determined the abundance ratios of Li/Ca for 7 Ba II stars, 5 M–S stars and 8 S stars. The Li content of the Ba II stars is similar to that of normal G-K giants. The M–S stars and 4 of the S stars resemble M giants in their Li abundance. Three S stars have $1 \sim 2$ orders of magnitudes more Li than typical M stars. In *Ap.J.*, **167**, 511 she gives from an abundance analysis of α Aur the result that the Li content of the F star is 15 times greater than in the G star. Catchpole (*M.N.*, **154**, 15p) found a high Li abundance in the Sco-Cen star HD 113703 ft (K0Ve). Boyarchuk (*I.C.A.O.*, **44**, 18) has found that Li is about 6 times overabundant in the atmosphere of K4II star 105 Her in comparison with the Sun and about 100 times overabundant compared with the average of Li abundance in K4 stars. However, Boyarchuk (*I.C.A.O.*, **46**) found the Li deficiency in flare star AD Leo as compared to non-flaring Barnard star. Zappala (*Ap.J.*, **172**, 57) obtained the Li abundance for F to K main-sequence stars in the Hyades, Pleiades, Praesepe and NGC 2264. No Li abundance is observed to exceed the present interstellar upper limit.

Feast (*M.N.*, **148**, 489) determined the wavelength of the Li λ 6708 line for 12 Li-rich F and G type stars. He says Li^7 is always the predominant isotope. There is some suggestion of two groups of stars one with the $Li^6/Li^7 = 0$ and another with the Li^6/Li^7 ratio $= 1/3$. It is interesting to note that Cohen (*Ap.J.*, **171**, 71) obtained the Li^6/Li^7 ratio of 0·1 or less for 14 bright F, G, and early K field stars.

ABSOLUTE PHOTOMETRY

Oke reports some activities of the Working Group on absolute spectrophotometry as follows: Work on absolute spectrophotometry by Hayes (*Ap.J.*, **159**, 165) and by Oke and Schild (*Ap.J.*, **161**, 1015), summarized in the last report, has now been published. A comparison of the lamp used by Hayes with that used by Oke and Schild has also been reported (*Ap.J.*, **162**, 361). Komarov and Pozigun (*A.Z.*, **47**, 551) have also done some calibration work in the far red and near infrared. Hayes is continuing his program of absolute calibration.

Y. FUJITA

President of the Commission

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ABBREVIATIONS

A.:	Astrofizika
A.A.:	Astron. and Astrophys.
A.A.S.:	Astron. and Astrophys. Suppl.
A.A.S.F.:	Ann. Acad. Sci. Fenn.
A.I.:	Astrophys. Invest.
A.J.:	Astron. Journ.
A.N.:	Astron. Nachr.
A.O.A.S.:	Astrophys. Obs. Acad. Sci. U.S.S.R.
Ap.J.:	Astrophys. Journ.
Ap.L.:	Astrophys. Letters
Ap.J.S.:	Astrophys. Journ. Suppl.
Ap.S.S.:	Astrophys. and Space Sci.
A.Z.:	Astron. Journ. U.S.S.R.
A.Zr.:	Astron. Zir.
B.A.A.A.:	Bol. Asoc. Argentina Astron.
B.A.A.S.:	Bull. Amer. Astron. Soc.
B.A.G.:	Bull. Astron. Inst. Czech.
B.O.T. y T.:	Bol. Obs. Tonantzintla y Tacubaya
C.O.A.A.:	Contr. Oss. Astrof. Asiago
C.R.:	C. R. Acad. Sci.
I.C.A.O.:	Izv. Crimean Astrophys. Obs.
K.O.B.:	Kodaikanal Obs. Bull.
L'A:	L'Astron.
M.K.O.:	Memoir Kodaikanal Obs.
M.N.:	Monthly Not. Roy. Astron. Soc.
M.R.A.S.:	Memoir Roy. Astron. Soc.
O.:	Observatory
P.A.S.A.:	Proc. Astron. Soc. Australia
P.A.S.J.:	Publ. Astron. Soc. Japan
P.A.S.P.:	Publ. Astron. Soc. Pacific
P.J.A.:	Proc. Japan Acad.
Q.J.R.A.S.:	Quart. Journ. Roy. Astron. Soc.
R.M.:	Rev. Real Acad. Cienc. Exactas Fis. Nat. Madrid
R.O.B.:	Royal Obs. Bull.
S.A.J.:	Soviet Astron. Journ.
S.R.T.U.:	Sci. Reports Tohoku Univ.
U.B.:	Urania Barcelona