

45. SPECTRAL CLASSIFICATIONS AND MULTI-BAND COLOUR INDICES
(COMMISSIONS DES CLASSIFICATIONS SPECTRALES ET INDICES
DE COULEUR A PLUSIEURS BANDES)

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1. Introduction

During the period covered, two important meetings dealing specifically with spectral classification have been held: (i) IAU Symp. 80 on the HR diagram was organized in Washington in November 1977 on the occasion of the 100th anniversary of H.N. Russell. The proceedings have been edited by A.G.D. Philip and D.S. Hayes. (ii) IAU Coll. 47 "Spectral Classification in the Future" brought participants to Vatican City in July 1978 to commemorate the 100th anniversary of the death of A. Secchi S.J. The proceedings will be edited by M. McCarthy, A.G.D. Philip and G.V. Coyne. The proceedings of the following meetings have been published: IAU Symp. 70 (Be and Shell Stars), IAU Symp. 72 (Abundance Effects in Classification), IAU Coll. 32 (The Physics of the Ap Stars). All included important papers on spectral classification.

2.1 Work Involving Slit Spectrograms (A. Slettebak)

Perhaps the most significant work since the last General Assembly in the use of slit spectra for spectral classification is the preparation and completion of spectral atlases which bring the MK system up to date: the Morgan-Abt-Tapscott atlas of the early-type stars and the Keenan-McNeil atlas of the later types. These and other important atlases of slit spectra are listed in Section 4 of this report.

O- and B-type Stars. Walborn (17.114.025) has discussed the OBN and OBC stars, and given a review paper on progress and problems in the upper left of the HR diagram (IAU Symp. 80). Heap (19.135.029) has discussed the spectral classification of O-type planetary nuclei. Garrison et al. (20.114.044) have classified 1113 OB stars in the southern hemisphere. Lesh (IAU Coll. 47) has made a comparison of luminosity calibrations for MK classifications of OB stars. Bisiacchi et al. (18.114.165) have carried out TV-Vidicon multichannel spectral classifications of O and B stars. Sinnerstad (IAU Coll. 47) has made a spectroscopic and photometric study of B2-B5 main-sequence stars. Roman (*Astron. J.* 83, p. 172, 1978) has provided spectral types for early-type stars observed by Skylab. Spectral classification of Of and Be stars was discussed by Andrillat (IAU Coll. 47). Hill and Lynas-Gray (20.113.005) provided MK spectral types for 193 northern early-type stars at intermediate galactic latitudes. Jaschek (20.114.032) discussed the present status of spectral classification in the conventional wavelength range, with emphasis on the early-type stars, while Bidelman (20.114.041) considered spectral classification from Copernicus data and Kondo (20.114.042) discussed the 2800 Å Mg II lines and spectral classification. Cucchiaro et al. (18.114.053, 20.114.021) have developed an ultraviolet spectral classification system for the B-type stars using TD1A, S2/68 observations.

A- and F-type Stars. Hill et al. (18.155.020) carried out spectral classification of A- and F-type stars at the north galactic pole. A.P. Cowley (17.114.036)

estimated spectral types of the bright F-type stars. Floquet (14.114.001) has provided spectral classification for some Ap and Am stars, while C.R. Cowley (IAU Coll. 47) introduced a classification scheme for the chemically peculiar late B- and A-type stars. Cucchiaro et al. (*Astron. Astrophys. Suppl.* 33, p. 15, 1978) have developed an ultraviolet spectral classification system for early A-type stars using TD1A, S2/68 observations.

Late-type Stars. Keenan is continuing his work to improve and extend the classification in the revised MK system of G, K and M stars. He is presently giving attention to the calibration of luminosity classes II, III and IV for stars of approximately solar composition. A practical classification for stars in the S-SC-C sequence has been devised by Keenan and Boeshaar (IAU Coll. 47), taking account of the work of Ake (IAU Symp. 80). Campbell, working with Garrison, has studied the classification of yellow giant stars in the near infrared using a reticon device on the Toronto classification spectrograph (18.158.221 and in press). Irwin, working with Bolton and Garrison, has synthesized low-dispersion spectra of yellow giant stars from stellar atmospheres theory and from high-dispersion spectra in order to study the effects of metallicity and microturbulence variations on the normal classification criteria (18.114.111 and in press).

Binary Stars. Hill et al. (14.114.047) have provided MK classifications for 186 close binary systems. Lutz and Lutz (19.118.009) have carried out spectral classification and *UBV* photometry of 91 visual binary systems.

Open Clusters and Associations. Abt (20.153.024), Abt and Levato (14.153.038, 17.152.010, 19.114.041, 20.153.025) and Levato and Malaroda (14.153.032, IAU Coll. 47) are continuing their work in spectral classification of stars in galactic clusters and associations. Abt (IAU Coll. 47) has also discussed the occurrence of abnormal stars in open clusters. Harris (17.153.023) has classified evolved stars in 25 open clusters. Hartoog (17.153.016) obtained MK types for 263 B- and A-type stars in southern open clusters to study the frequency of Ap and Am stars. Guetter (18.152.007, 18.152.019) did spectral classification of stars in the associations Ori OBl and Lac OBl. Garrison and Kormendy (19.153.006) classified stars in the cluster Trumpler 37, of which μ Cep (M2Ia) appears to be a member. Garrison has also classified several stars on the main sequence of NGC 6231, the nucleus of I Sco, down to $V = 14.4$ (approximately A0).

Magellanic Clouds. Feast (IAU Coll. 47) has discussed the future of MK classification work in the Magellanic Clouds. Walborn (19.159.015) has provided spectral classification of O and B0 supergiants in the Magellanic Clouds, and also pointed out a very early O-star in the Small Magellanic Cloud (*Astrophys. J. Letters* 224, L133, 1978). Dubois, Jaschek and Jaschek (*Astron. Astrophys.* 60, p. 205, 1977) discuss MK classification in the Small Magellanic Cloud. Fehrenbach (IAU Coll. 47) has considered the supergiant stars in the Large Magellanic Cloud, and the significance of luminosity class I.

General. Important review papers on various aspects of slit spectral classification were presented at IAU Colloquium 47 by Code, Garrison, Loden, Spinrad, and Walborn.

Garrison is classifying the 1300 brightest stars in both hemispheres in order to provide homogeneous classifications on the system of the new MK atlases as well as secondary classifications all over the sky. He is also observing a large number of stars in the ultraviolet at low resolution (6\AA) with the International Ultraviolet Explorer and will devise a classification scheme for them which will be independent of the MK system, but which will be compared with the MK system.

MacConnell and Alvarez have obtained spectrograms of 83 high-radial-velocity stars from an unpublished catalogue of Stock. The stars, with radial velocities

between 130 and 450 km/sec, have been classified by MacConnell, with types between B8V and M6III, including many weak-metal stars.

Ardeberg (IAU Coll. 47) has discussed the practical application of the MK and related spectral classification systems to spectrograms of various resolutions.

Slettebak and Kuzma (IAU Coll. 47) have considered the effects of stellar rotation on spectral classification, from the point of view of (1) the effects of plate resolution, and (2) physical changes in the rotating stellar atmospheres.

2.2 Objective Prism Spectra (A. Cowley)

S.W. McCuskey is continuing spectral classification of stars in LF12 ($\sim 8^h$, -25°) and LF14 ($\sim 12^h$, -61°). In LF14 spectral types have been determined for 8717 stars ($V > 12.5$) and luminosity classes as well for those stars with $V > 11$ and later than F8. A catalogue including spectral types, V magnitudes and identification charts is being prepared. In LF12 only B8-A2 and G8 III-K3 III stars are so far completed.

C.B. Stephenson and N. Sanduleak report on surveys for H α emission-line stars which might have been confused with OB stars in the earlier Cleveland-Hamburg surveys for luminous stars. Two recent publications now complete this work (19.114.052 and *Publ. Warner and Swasey Obs.* 2, no. 4, 1977). They are about to start a new H α survey of the entire northern sky above and below 10° galactic latitude and north of declination -25° . This will be done with the optically refurbished Burrell Schmidt with a 4° prism covering 5000-6800 \AA to look for both H α emission stars and carbon stars.

W. Iwanowska and S. Krawcyk are using 250 $\text{\AA}/\text{mm}$ objective prism spectra of about 40 non-variable carbon stars to establish classification criteria and look for population effects in these stars.

Th. Schmidt-Kaler, G. Diaz-Santanilla, R. Rudolph and H. Unger have presented a summary of their work "Quantitative Classification of Objective Prism Spectra" at IAU Symp. 80. Further low dispersion objective prism classification work in Southern Milky Way fields and in the Magellanic Clouds is under way.

K.G. Henize reports on a Michigan-Mt. Wilson southern H α survey (1929 emission-line stars $\delta < -25^\circ$ observed between 1949-1951) which has been published (17.114.042). The plates, now stored at the University of Texas, are available for historical reference concerning variable emission-line objects. Henize also gives a summary (19.032.557) of some of the findings of the Skylab S-019 UV Objective-Prism Survey which covers 9% of the sky. Widened spectra centered near 1550 \AA give useful data for moderately reddened B0 stars to about $V = 6.5$, while unwidened spectra at 2000 \AA can reach hot white dwarfs and subdwarfs as faint as $V = 12.0$.

Clariá and Stock (19.154.009) have used objective prism radial velocities to establish membership of late-type metal-poor stars and A stars in the halo of the globular cluster NGC 6397. Ibanez (19.112.012) had determined objective prism radial velocities of field Mira variables near the same cluster. Stock, working in the intermediate latitude region (RA 12.30-14.30, Dec. -30° to -35°) has determined positions, classifications, magnitudes and radial velocities for about 6000 stars. About 5% have velocities $> 100 \text{ km s}^{-1}$ relative to the LSR. Alvarez has determined velocities and types for 350 late-type giants in a field at 19.20, -32° . Stock and Vrba are working on classifications of all stars > 13.5 in fields surrounding the nearby dark clouds of CrA and Oph. Stock, Osborn and Clariá have given classifications, positions and magnitudes for 890 A and F supergiants in the LMC (17.159.005). Alvarez is studying the same stars in the ultraviolet for new type and abundance criteria. MacConnell and Bidelman have published classifications for 149 southern

luminous stars (17.114.029). MacConnell is preparing a series of catalogues of new H α emission stars, carbon stars and S stars found from his red survey of the southern galactic plane. There are about 1000 new emission-line objects, 40 carbon stars and about 170 MS and S stars.

N. Houk is continuing systematic reclassification of the southern HD stars on the MK system, using IIA0 plates obtained with the 10 $^{\circ}$ objective prism (108 Å/mm at H γ) on the Curtis Schmidt telescope at CTIO. Volume 2 of the Michigan Spectral Catalogue (Dec. -53 $^{\circ}$ to -40 $^{\circ}$; 30400 stars) is now being distributed. Volume 3, to be finished in 1980, will cover Dec. -40 $^{\circ}$ to -26 $^{\circ}$. Some results from Volumes 1 and 2 are published in the Proceedings of IAU Symp. 80 and IAU Coll. 47.

Bidelman is preparing a comprehensive compilation of identifications and spectral classifications for the stars contained in the Caltech Two-Micron Sky Survey. In addition to data from the literature, existing Warner and Swasey objective prism plates are being examined and new plates taken for this work. Sang Gak Lee, working with Bidelman, has determined spectral types for almost 900 objects contained in the Lowell Observatory Northern Hemisphere Proper-Motion Survey. Most of her classifications, done with Warner and Swasey Observatory objective prism material, relate to previously unclassified stars.

Red and near-photographic infrared spectra have been obtained by Pesch with the 4 $^{\circ}$ objective prism on the Burrell Schmidt for over 100 red stars with recently published trigonometric parallaxes (primarily from the U.S. Naval Observatory). One unusual object has been noted: G165-47, whose spectrum shows no TiO bands in spite of its large $V-I$ colour. This star is similar to the well-known sdMp star G95-59.

N. Sanduleak and A.G.D. Philip have published a list of 474 carbon stars and 609 suspected late-type supergiants in the LMC (*Publ. Warner and Swasey Obs.* 2, no. 5). These authors are now working on a survey of OB stars in both Clouds down to $V \sim 16$ using the Curtis Schmidt telescope at CTIO. A catalogue of probable dwarf stars of type M3 and later in the direction of the south galactic pole is now in press (*Astron. J.* 1978, Sept. by Pesch and Sanduleak). It includes $V + I$ photometry.

Robertson has completed a Ph.D. thesis "The Kinematics and Space Density of M Dwarf Stars". In an objective prism survey of 875 square degrees he found 200 M dwarfs brighter than $V \sim 13$. The luminosity function derived from these data agrees with Luyten's.

Bartaya reports that on the basis of the Abastumani Observatory 70 cm meniscus telescope with 8 $^{\circ}$ prism (dispersion 166 Å/mm near H γ) the spectral classification of 87 bright member stars of 12 open clusters (NGC 129, 457, 1907-1912, 2168, 6866, 6882, 6885, 7092, 7209, 7790, χ Per, h Per) is completed. Spectral classification of about 11000 stars is performed in the regions of O associations Cyg OB4, Cepheus-Lac OB1 and Cas OB9. In 14 McCormick Fields located in the vicinity of NGP the spectra of 2600 stars are classified, in 3 fields the quantitative two-dimensional spectral classification of F, G-type 200 stars is completed. The third parameter has been determined for 120 stars. Approximately 10 stars turned out to be metal deficient (D.M. Depadel'). On the basis of Abastumani Astrophysical Observatory data and in collaboration with the latter, following the methods developed by V.D. Malyuto, in Tartu, the quantitative spectral classification with definition of the metal abundance parameter of about 100 stars in the region of the NGP is completed (V.D. Malyuto, *Bull. Abast. Astrophys. Obs.*, in press). In Garmy Laboratory of Space Astronomy (GLSA) under the supervision of G.A. Gurzadyan a new method of spectral classification is developed. The character of the continuous spectrum

in the UV and especially the length of the spectrum itself significantly depend on the spectral type of the stars. The spectral classification of about 2000 stars has been completed. In so doing the stars mostly fainter than $10^m 00$ and up to $13^m 5$ were covered. Results can be found in 18.114.031, *Comm. Byurakan Obs.* 48, 5 and 14).

2.3 Automatic Spectral Classification (R.A. Bartaya)

Methodical work on automatic spectral classification is under way at Bochum Observatory (Schmidt-Kaler et al., 1976, *Forschungsber. Lunds-Nordrhein-Westfalen*, N2595).

A review paper by Schmidt-Kaler (IAU Coll. 47) considers the problem of automatic spectral classification. Special consideration is given to the classification of low and intermediate dispersion spectra and to application with the aid of photoelectric scanning detectors.

West (18.031.408) has considered the situation in automatic classification, in particular, of objective prism spectra. The experience in application of two-coordinate scanning means a step towards realization of automatic spectral survey. The experimental programme is initiated at ESO.

Mendoza (IAU Coll. 47) reports that in Mexico automatic MK spectral classification is achieved. It is based upon standard spectrograms obtained for visual classification. Computer results are given for all the MK standard stars earlier than B1. Slight modifications have to be done for later spectral types. There is a good correlation with the MK system. However, the results might be improved by using a rapid-scanning Michelson Fourier Transform Spectrophotometer to obtain the stellar spectra. The analysis of the interferograms should also be made by a computer.

Appenzeller and Zekl (IAU Coll. 47) at Heidelberg Observatory have developed a method to derive spectral types and absolute luminosities of stars automatically from classification spectrograms by means of a computer.

Kinman (IAU Coll. 47) in his report has discussed the problem of the possibility of spectral classification by means of digital method. An appropriate method is developed at Kitt Peak National Observatory.

The COSMOS automatic plate-measuring machine at the Royal Observatory, Edinburgh is intended for a fast surveying of the modern large Schmidt telescope negatives (both with direct images and low-dispersion spectra). Among the capabilities of COSMOS is a technique to separate automatically the images of galaxies from those of stars (MacGillivray et al., 18.031.402; Pratt, 19.031.428).

A scanning microphotometer with an on-line data reduction for large field Schmidt plates (Fritze et al. 19.034.085) was developed and put into operation at Tautenburg Observatory.

Radoslavova (19.031.427) has prepared a programme for treating absorption spectra on a computer with the aim of accurate and fast translation of transmissions into intensities and for computing equivalent line widths.

Barry, Cromwell and Schoolman (19.031.219) have developed a fast, automated data reduction procedure for quantitatively measuring stellar spectra to determine the fundamental stellar parameters of temperature, luminosity and metallicity.

In the ESO programme of discovering and studying the magnetic stars of the Southern Sky (PDS-1000) a digital microdensitometer is used (19.031.254).

3. Classification Employing Multi-Colour Work (B. Hauck)

An important book on stellar photometry has been published (in Russian) since the last report by Straižys: *Multicolour Stellar Photometry* (20.003.150). It is an excellent and useful compilation of all information about the various photometric systems.

Many theoretical colours are calculated, in particular by Bell and Gustafsson for giant stars (*IAU Symp. 80* and *Astron. Astrophys. Suppl.* in press) in the *UBVR*, Geneva, *wby*, DDO, *gnkmf*, Uppsala and Johnson et al. systems. Other theoretical colours are obtained for the Walraven system by Lub and Pel (19.113.012). Work is being carried out at the Institute of Basle with a wide variety of spectral scans combined with objective prism spectra and of model atmospheres for stars representing all major stellar types and population. Buser (*Astron. Astrophys.*: 62, pp. 411 and 425) has obtained results for the *UBV* and *RGU* systems and, in collaboration with Kurucz, has given a physical calibration of the *UBV* system for the early-type stars. The calculations of broad-band colours are now being extended to late-type giants, white dwarfs and subdwarfs (Buser). A study is being made of relations between metal content and colour indices, while an investigation of the possible multi-colour systems for three-dimensional classification of stars later than K5 has been commenced. Stellar energy fluxes were also used by Crawford and Mandwevala (19.113.011) to obtain an interstellar reddening relation in the *UBV*, *wby* and Geneva systems. Another problem concerning all systems is the obtaining of blanketing coefficients and many have been published: for the G, K and M giants (17.114.009), for the M0-M5 stars (18.114.169, 170), for the F5 stars (18.114.005) and for the UV spectrum of the B6 to A0 stars (19.114.008).

A. WIDE-BAND SYSTEMS

Many observations have been made in the *UBV* and its extension to the red and infrared. All measurements are collected at the Stellar Data Centre at Strasbourg. Some categories of stars were studied in this system: T Tauri in (17.113.002) and by Rydgren (17.113.035), who uses the J-H/H-R diagram to separate the effects of envelope emission and interstellar reddening; S stars by Feast et al. (17.113.007) who publish a mean bolometric absolute magnitude of -5.4 for these stars; C stars (17.113.008); barium stars by Catchpole et al. (20.114.027), who obtain spectra and *UBV* colours for 122 Ba stars and derive a mean absolute visual magnitude of -1; M dwarf stars by Mould and Hyland (18.113.003) who use the J-H/H-R diagram to segregate the populations and derive temperature and absolute magnitude; more recently Am stars by Mendoza (*Astron. J.* 83, p. 606) and Mermilliod, who is studying the blanketing effect on *U-B* and *B-V* (to be published).

Graphical correlations with the MK types have been obtained by Davis (19.114.030), while Deutschmann et al. (17.113.032) have published intrinsic colours for stars from O to M and luminosity classes from V to Ia. Kuriliene and Straižys (*Bull. Vilnius* 44, p. 3) have published also new intrinsic colour indices of supergiants. Alexander (19.113.057) has studied the accuracy of *R-I* as a temperature indicator and Hartwick (19.113.039) uses $\delta(B-R)$ as a measure of the metal deficiency of the subdwarfs. Buser has redetermined the response function for the *UBV* and *RGU* systems and the interstellar reddening parameters (*Astron. Astrophys.* 62, p. 411) and obtained a transformation formula between the two systems (*Astron. Astrophys.* 62, p. 425).

The *WBVR* system proposed by the Vilnius astronomers (*Trans. IAU XVII-2*, p. 100) was tested observationally (14.113.055). In 1976 the Sternberg Astronomical Institute (Khaliulin et al.) and the Main Astronomical Observatory of the Ukraine (Pugach et al.) started observations of standard stars. Up to 1978 more than 500

stars were observed.

The properties of the Walraven system are reviewed by Lub and Pel (19.113.012). Theoretical colours and applications to the three-dimensional classification of stars from A to G are presented. The subdwarfs are well segregated in a $(B-L)$ vs $(V-B)$ diagram and $\delta(V-B)$ is a good blanketing parameter. Th. and J.H. Walraven (20.159.007) have published many data, together with a comparison with the *UBV* system and also standard mean sequence relations.

Concerning the Geneva system, Goy has used various diagrams to obtain a photometric separation of the components of spectroscopic binaries (19.119.017), *Astron. Astrophys.* 64, p. 445) while Cramer and Maeder (to be published) have determined absolute magnitudes and temperatures, with a great internal accuracy, of the B stars. The photometric parameter of the peculiarity for the Ap stars was determined for 234 stars and a photometric determination of the stars classified Ap or Am in the Bertaud-Floquet catalogue was made (Hauck, *Astron. Astrophys.* 69, p. 685). A calibration of Δm_2 in terms of $[Fe/H]$ was published by Hauck (*Astron. Astrophys.* 63, p. 273). A study of the metallicity and rotation of the Am stars is now being made. Grenon (*Publ. Obs. Geneva, Série B, no 5*) has obtained calibrations in absolute magnitude, effective temperature and metal content for the G, K and M stars. Golay et al. (20.114.005) have applied the concept of "stellar boxes" and found that stars in the same box have nearly the same spectral type and nearly the same values as the parameters used in β , Copenhagen, UV and IR photometries. Golay (*Astron. Astrophys.* 62, p. 189) has shown that stars in the same box have the same absolute visual magnitude within a range less than ~ 0.1 mag. M. Jaschek et al. (IAU Coll. 47) have observed 380 stars at 80 Å/mm and concluded that stars belonging to the same box are spectroscopically identical at this dispersion. Fracassini and Pasinetti are at present studying the correlation between the blanketing parameter and absolute radius for 664 B5-F5V stars. For spectral types later than A5V, the single stars show average radii larger than those of multiple stars of the same spectral type.

Canterna (17.113.031) has used a new broad-band system (3910, 5085, 6330, 7885 Å) to obtain temperatures, metal abundances and a CN index for G and K giants. The metal abundances derived from the blanketing parameter are uncertain by a factor two.

B. MEDIUM-BAND SYSTEMS

Using the Vilnius system, Straizys (IAU Symp. 80) has proposed a method for classification based on five independent reddening-free parameters Q . The method is calibrated in T_e , $\log g$, spectral type and M_v . Many observations of various kinds of stars were made: Am and Ap (*Bull. Vilnius* 45, p. 13), Straizys and Zitkevicius, *Soviet Astron. J.* 54, p. 987), population II (Bartkevicius and Sperauskas), white dwarfs (18.126.053). Other measurements were made in various parts of the sky (*Bull. Vilnius* 52, 18.131.231). Kuriliene (*Bull. Vilnius* 44, p. 15) and Straizys and Kuriliene (*Bull. Vilnius* 47, p. 3) published intrinsic colour indices of the Vilnius system for stars of different spectral types and luminosities. Bartkevicius is preparing a catalogue of F-M type stars with metal deficiency. Plans to join the Vilnius and Geneva systems are being discussed and theoretical investigations made by Straizys, North and Hauck.

The magnitudes and colours of the DDO system given in (17.113.026) are the new standard of this system. A test of accuracy of low-dispersion objective-prism spectral classification of late-type stars is given in (18.114.044) while in (20.114.025) a method to derive MK types is presented by Yoss.

Philip and Perry have published (Vistas in Astronomy) a bibliography concerning the $uvby\beta$ system for the period 1950–1976. Many data were published, in particular in 17.113.057, 17.118.013, 18.113.010, 19.113.010, 19.113.001, 19.113.007, 20.113.027 and 20.113.028. Grönbech and Olsen (18.113.039) published a list of standard stars ($\delta < 10^\circ$). A calibration for the B stars is given by Crawford (*Astron. J.* 83, p. 48) while a luminosity calibration for the late-group (19.115.004) and F stars (*Astron. Astrophys.* 66, p. 335) is presented by Heck. For the OB stars luminosity calibrations are given in 18.115.002 by Klare and Neckel and also by Egret (*Astron. Astrophys.* 66, p. 275). Correlations with temperature are given in 19.113.031, 19.114.032, 20.114.055 and effects of stellar rotation are studied by W.H. Warren (17.113.001). A calibration of δm_1 in terms of [Fe/H] is given by Crawford in 18.113.023. A catalogue of 5083 dereddened stars was published (19.113.056) giving $\log g$, θ_e for most of the stars. Based on the new catalogue of Hauck and M. Mermilliod a preliminary updated version was prepared in June 1978 by Philip. Philip and Egret are applying Golay's method of stellar boxes to this new version.

The v , b and y filters were combined by Maitzen with two medium-band filters g_1 (5020 Å) and g_2 (5240 Å) to study the Ap stars (18.113.008). A new medium-band system with four colours (3530, 3980, 4930, 6550) is proposed (18.113.025). Data and study of solar-type stars in the 13-colour system are presented by Schuster (18.113.032).

C. NARROW-BAND SYSTEMS AND SCANS

In two papers concerning the BCD system, Chalonge and Divan (19.114.014, 015) have shown the possibility to segregate stars with different chemical composition, to calibrate this system in terms of [Fe/H] and to obtain for stars from O to F8 a good indicator of temperature.

Gerbaldi and Morguleff have performed an extensive analysis of the narrow-band spectrophotometric system started by Barbier and Morguleff for the B0 to F5 stars of all luminosity classes. Correlations with the MK types were obtained (IAU Coll. 47). In the near future, Gerbaldi and Morguleff will perform a multivariate analysis for the 800 stars measured in this system. This system was also used for a study of the Ap stars (Gerbaldi).

Massa and Lillie (*Astrophys. J.* 221, p. 833) have applied the vector space method to the O stars and interstellar reddening and have obtained intrinsic $H\beta$ values for the O and B stars.

K-line indices were obtained by Pedersen and Rudkjøbing (*Astron. Astrophys. Suppl.* 34, no. 3) for B, A and F stars. The Am stars were found to belong to an extended group of stars with relatively narrow K lines. Henry et al. (IAU Symp. 80) have also used K-line photometry to segregate the Am stars and to study the variations in metal abundance. Using the eight narrow bands system (0.7 to 1.1 μm), White and Wing (*Astrophys. J.* 222, p. 209) have classified the M supergiants.

Mendoza has employed a system of interference filters centered respectively on H α and at $\lambda 7774$ Å (neutral oxygen triplet). This system seems very suitable for the segregation of the Am stars (18.113.048, *Rev. Mexicana Astron. Astrofis.* 1, p. 363), the Ap stars (*Rev. Mexicana Astron. Astrofis.* 2, p. 259) and young objects (18.113.048, *Rev. Mexicana Astron. Astrofis.* 1, p. 363; 2, p. 29; 2, p. 33; 2, p. 231; 2, p. 259).

Rao and Mallik (*Mon. Not. R. Astron. Soc.* 183, p. 211) have derived a luminosity calibration for F5–G2 supergiants using the product of equivalent width

measures of OI 7774 Å and Fe I 7748 Å.

Many studies are based on scans. Kuan and Kuhi (17.114.037) presented the observations of O and Of stars, both kinds presenting evidence for effects of atmospheric extension. Effective temperatures of some Ap, Am and A stars were obtained by Babu (18.114.007), while Adelman (20.114.057), using Breger's catalogue (18.113.052), examined the energy distribution of Ap stars and pointed out the stars for which the features at $\lambda\lambda 4200$, 5200 and 6200 Å are present. At IAU Symp. 80 Greenstein presented results for multi-channel spectrophotometry of G, K and M stars of the main sequence and for fainter degenerate stars. The dMe are slightly above the main sequence and in the "cosmic scatter". At the same symposium, Gutierrez-Moreno and Moreno showed an analysis of photoelectric spectrophotometric observations in the Orion aggregate and the Upper Scorpion association. Concerning the cool stars, Gow (18.114.135, 120.114.053) observed barium, CH, and R-type carbon stars and Piccirillo the S stars (18.114.161). Maehara and Yamashita (17.122.038; *Ann. Tokyo Astron. Obs.*, in press) have carried out scanner observations of Mira variables and related stars and found that the colours between 3700 and 5500 Å are a good indicator of the intensities of TiO bands. Yamashita et al. (20.114.065) have obtained new spectral types in the C-system for 22 carbon stars. At the Uttar Pradesh Observatory, Rautela and Joshi have used spectral scans of M-type stars to define two indices ($M_{6250}-M_{5950}$, $M_{6500}-M_{5400}$). These indices can be used respectively to separate the M stars into spectral subclasses and luminosity classes. Rao (*Mon. Not. R. Astron. Soc.* 185) has measured with an automated scanner strengths of the G, CH and NH bands in weak G-based stars. New spectrophotometric calibrations of the absolute energy distribution of standard stars can be found in (18.114.135).

Spectrophotometric observations have been made in the UV at the Byurakan Observatory and the most important results can be found in 19.114.018, 019, 020, 021, 022, 023, 024, 025, 026.

4. Catalogues and Atlases (C. Jaschek)

Since the activity in the field of Commission 45 is increasing regularly, the number of catalogues is similarly increasing. Attention is called to two publications *Astronomical Catalogues 1951-1975* by M. Collins (20.002.025) and the reports of the Working Group of Commission 45 for the collection of photometric and spectroscopic data, which are published regularly (bi-annually) in the *Bulletin d'Information du Centre de Données Stellaires* at Strasbourg. In the latter the newest catalogues are listed, together with their availability on magnetic tape.

In what follows, we shall divide the catalogues into two classes (a) long observing lists and (b) lists of objects drawn from different sources. The note (CDS) means that the catalogue is only available at the Centre de Données, on magnetic tape.

CATALOGUES TYPE (A), SPECTROSCOPIC

L.O. Lodén et al.: A spectral survey of the Southern Milky Way III. O-B9 and M stars, $l = 280^\circ$ to 306° (17.114.008). Part IV is in preparation.

A. Cucchiaro et al.: Spectral classification from the ultraviolet line features of S2/68 spectra (18.114.053, 20.114.021, *Astron. Astrophys. Suppl.* 33, p. 15 and 35, no. 1)

V.I. Voroshilov et al.: Catalogue of *B*, *V* magnitudes and spectral classes of 1800 stars (18.113.001)

- J. Breger and A.M. Fringant: A search for faint blue stars in high galactic latitude (19.002.019).
- J. Andersen: A uniform edition of the Stockholm Southern Milky Way Survey (20.002.002).
- R.F. Garrison et al.: MK spectral classifications for southern OB stars (20.114.044).
- V.I. Voroshilov et al.: Catalogue of B , V magnitudes and spectral classes of 720 stars (20.002.049).
- N. Houk: University of Michigan Catalogue of two-dimensional spectral types for the HD stars. Vol. II. 30400 stars.
- R.A. Bartaya: Catalogue of MK classifications of 10396 stars (*Bull. Abastumani Astron. Obs.* 50, 1978).
- E.H. Geyer: Southern Milky Way spectral survey for stars earlier than A5 ($227 < l < 310$; $|b| < 9^{\circ}5$). 30000 stars. Bonn.
- N.B. Kalandadze and M.D. Metrevili: Spectra of 600 O, B and A stars (in preparation)
- R.F. Garrison: A catalog of MK types of the 1300 brightest stars. Toronto. (in preparation)
- P.C. Keenan: List of stars of types G, K and M classified on the revised MK system (about 500 stars). Perkins Observatory (in preparation).
- P.C. Keenan and P. Boeshaar: List of a representative selection of type S and SC stars. Perkins Observatory (in preparation).
- W.P. Bidelman: G.P. Kuiper's classifications of stars of large proper motion north of -50° . Cleveland (in preparation).

CATALOGUES TYPE (B), SPECTROSCOPIC

- M. Breger: Catalogue of spectrophotometric scans (18.113.053)
- G. Goy: A general O-type star catalogue. Third edition (18.114.054)
- M. Morel et al.: A catalogue of [Fe/H] determinations (18.114.130)
- C.B. Stephenson: A general catalog of S stars (18.114.141)
- W. Buscombe: Third general catalogue of MK stellar classifications (20.002.004)
- M. Jaschek: Catalogue of selected spectral types in the MK system. (CDS)
- P.M. Kennedy: MK classification extension. 1977 edition. (CDS)
- G.P. McCook and E.M. Sion: A catalogue of spectroscopically identified white dwarfs (20.002.048)
- A. Uesugi: Revised catalogue of stellar rotation velocities. Preliminary edition. Univ. of Tokyo (1978).
- I. Lundström and B. Stenholm: A planned new catalogue of the galactic WR stars. Lund Observatory (in preparation).
- A. Strobel and J. Strobel: Catalogue of abundance determinations. Torun (in preparation).
- R. Glebocki: Catalogue of stars having CaII H and K emissions. Gdansk (in preparation).

CATALOGUES TYPE (A), PHOTOMETRIC

- B. Grønbech and E.H. Olsen: Four colour *uvby* photometry for bright O to GO type stars south of declination $+10^{\circ}$ (18.113.010)
- L. Topaktas: *RGU* photometry of a field in the direction of galactic longitude 330° (18.113.014)
- F. Rufener: Second catalogue of stars measured in the Geneva Observatory photometric system (18.113.056)
- S. Wrandemark: *B* and *V* magnitudes and spectrophotometric quantities of stars in a field centered at $l = 36^{\circ}$, $b = +8^{\circ}3$ (18.113.077)
- B. Grønbech and E.H. Olsen: Photoelectric $H\beta$ photometry for bright O to GO type stars south of $\delta = +10^{\circ}$ (19.113.010)
- M. Golay and N. Mandwewala: Catalogue of photometric star boxes in the Geneva system (20.002.038)
- G. Klare and T. Neckel: *UBV*, $H\beta$ and polarization measurements of 1660 southern OB stars (19.113.008)
- W.H. Warren, Jr. and J.E. Hesser: Catalog of individual *UBV* and *uvby photoelectric observations of stars in the Orion OBI association (19.152.010)*
- J.K. Knude: Photoelectric *uvby* and $H\beta$ photometric of 750 A and F stars in 63 selected areas within $|b| < 30^{\circ}$ (20.113.028)
- A.M. Spaenhauer: *RGU* three-colour photometry of a field in Aquila near NGC 6755 (20.155.023)
- H. Steppe: The Basle catalogue of blue objects in higher galactic latitudes in SA 51, 54, 82 and in the Halo field around M5
- Th. Walraven and J.H. Walraven: Five-channel photometric observations of stars in the Magellanic Clouds and in the Milky Way (20.159.007)
- R.F. Wing: Classification and photometry of giants and supergiants K4-M8 in the "Bright Star Catalogue". Perkins Observatory.

CATALOGUES TYPE (B), PHOTOMETRIC

- J.C. Mermilliod: Catalogue of *UBV* photometry and MK spectral types in open clusters (18.153.023)
- J.C. Mermilliod and B. Nicolet: A general catalogue of *UBV* photoelectric photometry (20.002.003)
- B. Nicolet: Catalogue of homogeneous data in the *UBV* photoelectric photometric system (*Astron. Astrophys. Suppl.* 34, p. 1, 1978)
- M. Morel and P. Magnenat: Catalogue of *UBVRIJKLMNH* measurements (*Astron. Astrophys. Suppl.* 34, p. 477, 1978)
- B. Hauck and M. Mermilliod: *uvby photometric catalogue. Institut d'Astronomie, Lausanne (new edition in preparation)*

ATLASES

- H. Johnson: The atlas of stellar spectra (19.002.044)
- W. Seitter: Atlas for objective prism spectra. Bonner spectral atlas II (original dispersion 645, 1280 A/mm) (19.002.068)
- P. Keenan and R.C. McNeil: An atlas of spectra of the cooler stars: types G, K, M, S and C (18.114.132)

- J. Landi-Dessy, M. Jaschek and C. Jaschek: An atlas of grating spectra at intermediate dispersion (original dispersion 42 A/mm). Cordoba University, Argentina
- Y. Yamashita et al.: An atlas of representative stellar spectra (original dispersion 73 A/mm). University of Tokyo Press (1977)
- A. Cucchiaro, M. Jaschek and C. Jaschek: An atlas of ultraviolet stellar spectra ($\lambda\lambda$ 1350-2740). Liège-Strasbourg Observatories.
- A.M. Hubert-Delplace and H. Hubert: Un atlas d'étoiles Be. Observatoire de Paris-Meudon and Observatoire de Haute-Provence (in preparation).
- W.W. Morgan, H.A. Abt and J.W. Tapscott: Revised MK atlas for stars earlier than the Sun

MISCELLANEOUS

- D.S. Mathewson et al.: Polarization catalogue. (CDS)
- M. Fracassini and L.E. Pasinetti: Catalogue of stellar diameters. Milano-Merate Observatories (in preparation).

5. Conclusion

Many important works have been published during the period covered and most of them are listed above. It is interesting to note the large increase of studies on spectral classification in the ultraviolet, the ever-increasing use of scans for classification and related problems of coolest stars and the great amount of data published during this period. Finally I think it necessary to mention that the spectral type and colours of the Sun are always a very controversial problem which has been discussed in some papers (e.g. Barry (21.114.004), Barry et al. (*Astrophys. J.* 222, p. 1032), Hardorp (21.114.006), Schuster (18.113.032) and Garrison (IAU Coll. 47)).

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