

45. STELLAR CLASSIFICATION (CLASSIFICATION STELLAIRE)

PRESIDENT: V. Straižys

VICE-PRESIDENT: R. F. Garrison

ORGANIZING COMMITTEE: R. A. Bell, M. Golay, A. Heck, M. Jaschek, D. J. MacConnell, A. G. D. Philip, A. Slettebak

I. INTRODUCTION

During the report period (1982–1984) several symposia, colloquia, and workshops in the field of stellar classification were held. These include: IAU Symposium No. 111 "Calibration of Fundamental Stellar Quantities" (Como, May 24–29, 1984, ed. D. S. Hayes et al.), IAU Colloquium No. 76 "The Nearby Stars and the Stellar Luminosity Function" (Middletown, June 13–16, 1983, ed. A. G. Davis Philip and A. R. Uggren), IAU Colloquium No. 78 "Astronomy with Schmidt-Type Telescopes" (Asiago, August 30 – September 2, 1983, ed. M. Capaccioli), the workshop "The MK Process and Stellar Classification" (Toronto, June 6–10, 1983, ed. R. F. Garrison), the Colloquium "Cool Stars with Excess of Heavy Elements" (Strasbourg, July 3–6, 1984).

II. CLASSIFICATION USING SLIT SPECTROSCOPY (R. F. Garrison)

(a) O- and B-type Stars.

Wolf-Rayet stars in the Galaxy were the subject of several papers: Silversten (29.114.030), Thevenin et al. (31.114.051), Heap (32.114.133), Mendez and Niemela (32.114.136), Lamontagne et al. (33.114.101), Massey and Conti (34.114.029), Torres and Conti (ApJ 280,181), and Lundstrom and Stenholm (AA Suppl. 56,43). Other peculiar stars studied include He-strong stars (Drilling, 30.114.151; Walborn (33.114.082), subdwarfs (Drilling, 34.126.001), peculiar supergiants (Swings, 29.114.091; Turner and Drilling, PASP 96,292), high-latitude stars (Tobin and Kilkenny, 29.114.008; Hobbs et al., 32.155.060; Walborn, 33.116.007), Bp stars (Hobbs et al., 34.131.095), and white dwarfs (Wegner, 34.126.003). Apparently normal O- and B-type stars were classified by Forte and Orsatti (29.114.033), Walborn (29.114.045, 32.114.081), Drilling and Perry (30.114.079), Bassino et al. (32.113.043), Aab et al. (34.117.163), and Forbes (AJ 89,475). Classification criteria, standards and methods have been discussed by Walborn (31.114.023), Bisiacchi et al. (31.114.045), Barsukova et al. (33.002.001), and Turner and Lyons (33.114.095). Classification of slit spectra for ultraviolet objects was carried out by Dworetsky et al. (32.114.008, 32.114.168). An atlas of yellow-red spectra of OB stars has been published by Walborn (29.002.011).

(b) A- and F-Stars.

Wolff (34.003.159) has produced a comprehensive summary of the classification of normal and peculiar A stars. Bouw (29.114.147) classified supergiants in the infrared, and Böhm-Vitense (32.114.201) has suggested ultraviolet criteria for A-star classification. Gray, working with Garrison, has refined the MK System for the A stars and reclassified most of the bright A stars. Peña et al. (29.122.162, 31.122.015) classified δ Scuti stars, while Hauck and Slettebak (34.113.021) and Abt ("The MK Process") studied λ Bootis stars. The variable A-type supergiant suggested as an x-ray source identification by Garrison and Krzeminski in 1973, has been further studied by van Genderen et al. (34.113.005). Abt et al. have classified HD 164615 as a spotted star (34.122.063). Hauck (32.002.107) has published a supplemental catalogue of Am stars. Rao and Rajamohan (JAA India 3,267) have studied the peculiar star HD 147010. Glaspey (32.115.002) has identified HD 105262 as a possible horizontal-branch star and Garrison and Fernie (ApJ 285,698) have pointed out a serious discrepancy between photometry and spectral type for HD 161796, but reconfirmed Bidelman's type of F3 Ib. Slettebak (32.114.054) has published types for the brighter Be stars and A-F shell stars, and Lutz (ApJ 279, 714) has studied the unusual emission-line object HDE 330036.

(c) Late-type Stars.

Morgan et al. (29.114.049) have reviewed the classification of F and G supergiants and Keenan (34.114.024) has updated his large list of classifications for stars later than G0. Keenan (30.114.143, 31.114.212) has reviewed problems of classification for the red giant stars and Egret, Keenan and Heck (31.115.006) recalibrated the red giant absolute magnitudes. Red dwarfs were classified by Walker (30.114.013, 34.114.082) and by Cowley and Hartwick (31.111.001). Harlan (30.114.177) continued his series on classifications of F-G stars.

While still not using MK spectra or techniques, Hardorp (31.114.010, 31.114.047, 32.114.033) continued to obliquely discuss the MK type of the Sun. Garrison and Zimmerman (33.071.037) have determined integrated MK spectrum of the Solar disk: it was found to be consistent with a type of G2 V and not with a later type. Garrison is classifying all of Hardorp's candidates to the Solar analog with proper MK spectra to provide homogeneous types.

Barium stars were classified by Yamashita and Norimoto (30.114.201) and by Lü et al. (33.002.043). The S star Pi Gruis was studied by Murty (34.114.021). A G star surrounded by nebulosity has been classified by Vogt et al. (29.112.011) and the G-type supergiant HD 179315 has been rediscussed by Fernie and Garrison (30.122.027).

(d) Binaries and Multiples.

During this period, four comprehensive studies have been made: Abt (30.152.002) has classified 865 components of visual multiples, Corbally (ApJ Suppl. 55,657) has classified the components of 170 close visual pairs, Haldebel (PASP 96, 98 and IBVS Nos. 2549 and 2550) has given types for eclipsing systems, and Gahm et al. (33.118.003) classified visual doubles with early-type primaries. Some composite spectra were studied by Naftilan and Milone (30.120.006). Groote and Reimers (33.114.023) have classified the companion of HD 63032 and Menzies et al. (34.118.003) have classified a pair of late-type giants. Wolf-Rayet binaries were studied by Lamontagne et al. (33.114.101), Willis and Stickland (34.117.050), and Turner et al. (34.153.004). A, Am, and Ap binaries have been classified by Hube (30.118.015), Abt (29.118.009), Abt and Cardona (34.153.019 and ApJ 276,266), and Ginestet et al. (31.120.008). Close binaries were analyzed by Young and Schneider (30.117.007), Hutchings and Crampton (30.117.051), and Green et al. (ApJ 280,177). Allen (Proc. ASA 5,369) has compiled a catalogue of symbiotic stars, Huang (32.114.155) has classified the symbiotic star AG Dra, while Andriolat (32.114.148,149) studied the infrared spectra of symbiotic stars.

(e) Variable Stars.

Comprehensive classification studies have been made of Mira variables by Crowe (JRASC 78,103, "The MK Process" and ApJ Suppl., in press), of Cepheids by Garrison and Gauthier ("The MK Process" and ApJ Suppl., in press), of δ Scuti stars by Peña, Peniche et al. (29.122.162, 31.122.015, 33.122.150), and of helium-strong stars by Walborn (31.114.213). Walborn (29.122.022) has also found systematic variations in the spectrum of θ' Ori C.

Garrison et al. (ApJ 276,L13) have used classification techniques to discover the brightest-known cataclysmic variable, and van Genderen et al. (34.113.005) have confirmed Garrison's A2 Iaep classification of the variable supergiant CD-33^o12119. Chincarini and Walker (30.117.097) has classified AE Aquarii primary as the K5 V star.

Lloyd Evans (Obs. 103,276) has studied carbon stars among type II Cepheids and Parsons (29.122.048) has classified the probable Cepheid HR 4511 and its hot supergiant companion. Chavarria (30.121.002) has studied a peculiar T Tauri star.

(f) Clusters and Associations.

Levato and Malaroda classified MK spectra in three young clusters (31.153.002, 32.153.037, ApLetters 24,37) and Turner, Forbes et al. (29.153.009, 30.153.011, 32.152.001, 32.153.036, 33.152.002, 34.153.004, ApJ 283,254) classified stars in several young clusters, especially those with an associated Cepheid. Herbst and Warner (30.121.001, 31.152.001) continued their series on classifications in R associations, while Marraco and Rydgren (29.152.005) and Vrba and Rydgren (ApJ 283,123) classified stars in T associations. Orion stars were classified by several, including Geutter (30.152.002), Derviz (34.114.036), and Walker (34.153.014). FitzGerald and Müller (34.153.013) classified stars in Stock 14. Claria has studied NGC 2547 (Bol. Ass. Astr. Arg. No. 27,115) and work is in progress on IC 2395 and several trapezium systems. Slettebak is classifying Be stars in NGC 663, the Perseus Double Cluster, NGC 2421, 2439, 2516, 2581, 3766, and 4755.

In work on intermediate-age clusters, Corbally and Garrison (33.153.018) classified stars in the lower main sequence of Praesepe and recently extended their work to K4 at B = 15.6 with good MK spectra. Arellano, Garrison, and Gray are re-classifying the bright Praesepe stars. Smith and Hesser (33.154.035) classified stars in NGC 2477 and Breger (AASuppl. 57,217) classified Pleiades stars. Rose (AJ 89,1238) classified Hyades and Pleiades stars, but not on the MK System. Gray, working with Garrison, is reclassifying all the A stars in several bright clusters. Common proper motion groups were studied by Lü and Tsay (31.152.010, 34.152.007).

Globular cluster stars were classified by Lloyd Evans (34.154.020, MNRAS 209,825), McClure and Hesser (31.154.036), and Smith and Norris (AJ 89,263). S-type stars in ω Centauri have been detected.

(g) Stars in galaxies.

WR stars in the LMC were classified by Breysacher et al. (31.159.030), Conti and Garmany (32.114.139, 34.114.004), Stahl et al. (34.122.067), and Walborn (31.159.014). WR stars were classified in the SMC by Moffat (31.159.029) and in M33 by D'Odorico and Rosa (31.114.169). Other OB star classifications in galaxies include those in the Clouds by Shore and Sanduleak (34.114.064, ApJ Suppl. 55,1), Walborn (33.159.004), and Crampton and Greasley (31.159.026). Humphreys (33.156.002) classified luminous stars in the SMC. Carbon stars in the Clouds were classified by Richer (29.159.005) and Bessell et al. (33.153.003). A CH star in the direction of the LMC has been described by Fehrenbach and Dufloot (30.111.001). In the Clouds Lloyd Evans (34.156.004, MNRAS 208, 447) classified M and S stars and Wood et al. (34.156.008) classified long-period variables.

(h) General

In the volume "The MK Process" Mihalas, Morgan, and Keenan have presented some very important philosophical remarks concerning the distinction between the MK System and the MK Process by which it was established and Gray has discussed the application of new detectors to classification work. Morgan et al. (29.114.049) have discussed the classification of the Hertzsprung gap supergiants. Milone (29.114.129) has discussed classification at 42 \AA/mm . The Jascheks (32.114.176) have given a general review of spectral classification. A new system of classification for white dwarfs has been suggested by Sion et al. (32.126.030). Danks and Dennefeld (32.114.197) have extended the MK classification system into the near infrared up to 11000 Å. Greidanus and Tinbergen (32.002.100) and Jacoby et al. (ApJ Suppl. 56,257) have published the libraries of digitized spectra of stars classified in the MK System.

Hoffleit (31.002.007) has updated the Bright Star Catalogue with classifications from the literature and has extended (Supplement, 1984) it to include stars up to 7 mag. She has also discussed errata in the La Plata catalogue (29.002.016). Buscombe (31.002.078) continued to publish his catalogues without bothering to give references; his catalogues have been commented upon by Kharadze (32.002.105). Documentation for the Morris-Kennedy (1983) catalogue has been given by Warren (34.002.091). Benest (34.155.104) has discussed the distribution of types in the Solar neighborhood. MacConnell (in preparation) has classified 82 faint, high-velocity stars with a range of types from B to M.

III. OBJECTIVE-PRISM SPECTRAL CLASSIFICATION AND CLASSIFICATION INVOLVING AUTOMATIC METHODS (D. J. MacConnell)

(a) Objective-prism work in the Galaxy.

(1) **General.** The third volume of the Michigan Spectral Catalogue (32.002.126) has appeared containing N. Houk's MK types for 30314 HD stars between -40° and -26° . "A Second Atlas of Objective-Prism Spectra" (Houk and Newberry, U. of Michigan, 1984) has been published and it contains stars over a wider temperature and luminosity range than the first one. Vol. 4 of the Catalogue is to be published early in 1986 and it will have a northern cut-off at -12° . Bidelman (34.114.006) has reported on his survey of the first 100 plates taken for the northern HD reclassification project and listed 175 new peculiar and interesting stars. As of this writing, 50% of the plates necessary to cover the remaining northern sky have been taken. High proper motion stars were classified by MacConnell (34.114.128) and Lee (AJ 89, 702). Bidelman and MacConnell (31.123.033) have presented 27 southern stars of various peculiarity groups, and Jensen (30.114.080) has given MK types for 167 northern HD stars. Bartaya and Kharadze in the Abastumani were working on two-dimensional classification of 12000 stars to mag 13 in SA 44-67. Kuznetsov (31.114.088) has reviewed methods of low dispersion spectral classification.

(2) Surveys in the Galactic plane.

Ha-emission stars. Maehara (31.114.201) reports on 19 em. stars found on Kiso and Bosscha plates. Ogura and Hasegawa (34.121.005) searched 15 Bok globules and has found 48 new em. stars, and Ogura (PASJ 36, 139) has found 135 new ones concentrated around NGC 2264. Parsamian (31.114.066) has reported on the total number of em. stars in the Orion Nebula region (~ 450) including her new findings, and Parsamian and Chavira (34.002.132) have compiled a major catalogue of em. stars in the Orion Nebula region. Tsvetkova and Tsvetkov (31.114.161) has discussed their new em. stars in the region of γ Cyg. MacConnell (31.114.161) has found 107 new em. stars along the southern plane, and Vega (31.114.092) has found 108 in Vela. Kun (32.114.004) has found 110 new em. stars in two fields with several dark clouds. Duerr et al. (32.121.009) have found 21 new em. stars in the region of the λ Ori cloud complex. Arkipova (33.114.084) has published a review of spectral observations of hot em. stars observed with the 50-cm telescope at Crimea, and Kohoutek (34.013.079) reports on the Hamburg/Calar Alto survey of the northern Milky Way. MacConnell and Coyne (Publ. Vatican Obs. 2, Nos. 5, 6, 1983) have revised Parts I-V of the Vatican survey and have given 215 new stars along the northern plane.

Early-type stars. Vega and Muzzio (30.115.024) have discussed the relation between types determined from thin-prism plates and those of higher dispersion for OB stars. Peton-Jonas (30.155.013) gives types for 102 O and B stars in Puppis. The following papers contain classification in the vicinities of the open clusters: Kun (33.152.005) at NGC 7160, Paparo and Balazs (33.155.124) at IC 4665, Gieseking (33.153.002) at Cr 70, Kalandadze and Voroshilov (33.132.046) at NGC 1499, and Christian (32.153.010) at Be 21.

Late-type stars. Maehara (PASJ, in press) has classified carbon stars on the C-system in Cas, Raharto et al. (Ann. Tokyo Obs., 19, No. 4) have published a catalogue of over 2000 M stars, and Hamajima et al. (31.114.202,203) have presented results of their collaborative work using the Kiso and Bosscha telescopes searching for cool stars toward the Galactic center. Mikami et al. (32.155.009) have classified IR sources in Sct. Alksnis et al. (30.114.191, 34.114.047,100; Investig. of the Sun and red stars, 19, 40) have discussed their discoveries of new carbon stars at Baldone. Kurtanidze and Nikolashvili (31.114.065) have reported 40 new carbon stars in Cas. Smriglio and Nandy (31.114.194,195) have discussed spectrophotometry of M stars in Mon and Cep.

(3) Surveys out of the plane.

Stephenson (34.155.103) has completed his visual-red survey north of dec. -25° and further than 10° from the plane and has discovered about 300 new H α emission stars and over 1000 new K and M dwarfs. Stock (Rev. Mex. A. A. 9, 77) has published the details of his catalogue of over 10000 stars giving positions, types, and indicative radial velocities; the catalogue may be obtained by writing to him. As a result of the Case northern sky survey (33.002.004 and ApJ Suppl. 55, 517), Sanduleak is preparing for publication a list of 184 early-type stars and suspected blue horizontal-branch stars toward the NGP. He also is finding possible new HB members of globular clusters at considerable angular distances from them. Fehrenbach and his collaborators continued their classification and radial velocity work toward the MC (30.111.001 and AA Suppl. 55, 103) and in 4 fields a b $\sim 30^\circ$ (32.111.001). Schiller (31.155.038) surveyed 840 sq. deg. at the SGP and has found 183 M stars to $m_{\text{pg}} 14.7$. Recillas-Cruz (32.114.108) searched for early-type stars in the direction of the Magellanic Stream. Erculiani (31.141.086) has classified 186 blue objects in the field of 88 Leo. Robertson (34.155.131 and AJ 89, 1229) has presented his work on the kinematics and lum. function of late M dwarfs found on red objective prism plates. Smethells (34.155.134) has given a reanalysis of his southern early M-dwarf survey. Staller et al. (31.155.003) used grism plates to examine the nature of 2600 red stars at the SGP.

(b) Objective-prism and grism work in the Magellanic Clouds and other galaxies.

Sanduleak and Pesch (30.159.008) have reported finding 5 possible new VV Cep stars in the SMC. Prevot et al. (34.156.001) have presented nearly 200 K and M supergiants in the SMC. Rebeiro et al. have detected over 260 new M stars which are presumably members of the LMC. Philip and Sanduleak (33.156.016) have presented their comprehensive list of LMC OB and supergiant stars. Shore and Sanduleak (ApJ Suppl. 55, 1) have given a detailed description of the spectra of 21 early-type, strong emission stars in both Clouds. Mould et al. (31.158.042) have reported finding 8 carbon stars in the Carina dwarf spheroidal galaxy.

There has been much recent activity using "grisms" at the prime focus of major telescopes, and much of this effort was directed toward members of the Local Group. Blanco and McCarthy (34.156.007,012) have discussed their findings on the distribution of C and M giants in the MCs from their near-IR grism spectra, and in IAU Symp. 108 ("Structure and Evolution of the Mag. Clouds", 1983) they have presented their classification scheme. In AJ 89, 636 they and B. Blanco have given the results of their survey for M giants in the Baade's Window. Blanco et al. (30.159.009) have reported the discovery of the first S star in the SMC. Westerlund et al. (33.114.098) have described their program to search for WR stars in galaxies. Several groups have reported their results of surveys for carbon stars in Local Group galaxies: Richer and Westerlund (33.157.003) and Aaronson et al. (31.158.043, 32.158.133,303,304; 33.157.031, 34.157.143). Carbon stars have been found in 7 of the local dwarf spheroidal galaxies.

(c) Automated Classification.

Several groups were active in this area and have reported substantial progress. Schmidt-Kaler (32.031.648) has given a survey report on the goals and methods, and Kurtz ("The MK Process" workshop) has also presented an excellent review. The methods may be divided into three groups: a) quantitative measurements for evaluation of criteria, b) pattern recognition and cross-correlation techniques, and c) combined procedures. Malyuto et al. (30.031.653, 32.114.065, 32.031.655, 33.114.108, and IAU Coll. 78, Asiago, p. 287) are developing the method to determine temperatures, luminosities, and metallicities from low dispersion objective-prism spectra digitized with a PDS. For calibration they use about 150 F-K standard stars and apply a linear polynomial regression model for the fitting. Zekl (31.031.542, 32.031.650) uses Cassegrain spectra for 2-dimensional classification of normal stars in the range B0-K3. Tobin and Nordsieck (30.114.092) have obtained spectra of 26 weak-metal stars with an intensified diode-array scanner over a wide wavelength range and have made mathematical models of the absorption features' dependence on color, luminosity, and metallicity. Kelly et al. (31.114.018) have described their program of microdensitometry of very low-dispersion UK Schmidt plates. Ratnatunga and Freeman (IAU Coll. 78, Asiago) present their automated analysis of plates to locate distant field halo K giants and report a high rate of success. Kurtz (32.031.649) has made important progress in the use of pattern recognition, cross-correlation, and Euclidean metric techniques over the whole MK spectral domain. Bijaoui (30.111.005, 32.031.653, 33.036.129) also applies pattern recognition methods to problems of stellar classification. Simien (32.031.652) uses cross-correlation to find rough spectral classes which are then improved by the evaluation of specific criteria. Luminosity classification presents too many difficulties, however.

Automated classification techniques has been also discussed at the June 1982 meeting of the Scientific Council of the C. D. S. (Bull. Inf. CDS, No. 23) and at the Sept. 1982 "Workshop on Astronomical Measuring Machines" (33.012.059).

IV. CLASSIFICATION FROM EXTRAATMOSPHERIC SPECTRA (A. Heck)

Most of the work in this field during the period was based on spectra collected by the International Ultraviolet Explorer (IUE). A workshop on UV stellar classification has been organized in October 1981 at VILSPA (32.012.062 - ESA SP-182) with contributions of Cucchiario (32.114.195), Jaschek and Jaschek (32.114.196), Wesselius (32.113.059), Wu et al. (32.002.115), Heck (32.013.095), Benvenuti (32.002.116), Danks and Dennefeld (32.114.197), Nandy (32.114.198), Praderie (32.114.199), Baschek (32.114.200), and Böhmer-Vitense (32.114.201), reviewing the classifications

carried out from TD1 and ANS data, as well as the work in progress with IUE spectra, together with theoretical considerations. At the Toronto MK workshop, the Jascheks presented their morphological classification from a sample of IUE low-resolution spectra of O–G normal stars, on which the first volume of the IUE low-dispersion reference atlas (Heck et al., 1984, ESA SP-1052) has been built. An objective statistical classification on the same material has been carried out by Heck et al. (32.114.102; ESA SP-218, 1984, p. 257), confirming Jascheks' frame and the fact that one cannot simply transfer MK classifications to the ultraviolet spectral range. Walborn and Panek ("The MK Process" workshop and ApJ, 280, L27) pointed out Si IV as a luminosity criterion for O-type stars from a sample of IUE high-resolution spectra. The resulting frame allows also to identify some anomalies in the CNO features among the ON and OC stars. Walborn et al. (ESA SP-218, 1984, p. 255) also announced an IUE high-resolution atlas of O-type spectra based on these discriminative features. Rountree et al. announced (IAU Symp. 111, Como) a classification of B stars based on IUE SWP high-resolution spectra. Baschek et al. (AA 131, 378) offered a discrimination of λ Bootis stars based on strong identified (CI 1657 Å and CI 1931 Å) and unidentified (1600 Å and 3040 Å) absorption features. Henize et al. (30.114.163) used low-dispersion UV spectra from the S-019 Skylab experiment for a classification of O–B2 stars, particularly by using the Si IV/C IV ratio as a luminosity criterion among O stars, and as a temperature criterion among O9–B2 stars of lower luminosity. Sakhibullin and Solovjev (32.114.177) investigated a possibility of spectral classification of B0–A1 stars based on the ratio $I(2831 \text{ Å})/I(2843 \text{ Å})$ from TD1 observations. Ultraviolet classification was discussed for F–G dwarfs by Garcia-Alegre (29.114.061) and for carbon and S stars by O'Brien and Johnson (32.114.216) and Johnson (Coll. Cool Stars with Excess of Heavy Elements, Strasbourg, 1984). The IUE Ultraviolet Spectral Atlas (Wu et al., 34.002.083) containing a wide representative set of spectral types and luminosities has been published. Wing et al. (34.002.086) has produced an atlas of IUE high resolution spectra of late-type stars, and Benvenuti et al. (34.002.085) of supernovae. Koornneef et al. (31.113.009) have published an atlas of energy distributions for 531 stars in the wavelength range λ 1330–5500 Å based on OAO-2, TD-1, and ANS results.

V. CLASSIFICATION USING MULTICOLOR PHOTOMETRY (V. Straižys)

(a) Wide-Band Systems

Several varieties of the superwide photographic UJFN system intended for crude classification of stars, galaxies and quasars were used (Kron and Chiu, 30.141.074; Koo and Kron, 31.141.016; Couch and Newell, 32.113.005). Schild and Kent (SPIE 290, 186, 1981) have realized a similar system with the CCD. The photometric systems to be used in the Space Telescope and Hipparcos – Tycho experiment were discussed by Westphal (32.032.513), Hog et al. (31.051.019,020), Argue (32.051.078) and Granes and Mignard (34.113.062). The arguments in favour of the revision of the UB system have been presented by Straižys (34.113.059). Observations in the revised WBVR system have been published by Dorokhov et al. (*Problemy kosm. fiziki*, Kiev, 19, 102). *New intrinsic color indices in the VRIJHKL system* have been published by Wing (34.114.045), The et al. (AA 132, 385) and Koornneef (34.113.025). Discovery and investigation of very cool infrared stars in 1983 is related with the IRAS satellite which made an infrared sky survey at 12, 25, 60, and 100 μm (see ApJ Letters 278, No. 1). The RGU system was used to recognize the metal-deficient stars (Buser, 32.155.054; Spaenhauer et al., 31.031.571; 32.155.057; Messenger 36, 6; Thevenin et al., 34.113.006). The Washington system was used for metallicity determination of red giants in open clusters (Claria and Lapasset, 34.153.042; MNRAS, in press). The classification properties of the Washington system were investigated by Straižys and Kurilienė (Bull. Vilnius Obs. 62, 39).

(b) Medium-Band Systems

1. **The uvby β system.** Observations and studies of the following objects have been published: field A5–G0 stars (Olsen, 34.002.029; AA Suppl. 56, 229), B-type stars (Westin, 32.113.003; Tobin, AA Suppl. 56, 221; 57, 427, and Zhang, 33.113.053), F-type stars (Eggen, AJ 89, 1606), late-type dwarfs (Olsen, AA Suppl. 57, 443), stars nearer than 100 pc (Perry et al., 32.131.296,309), NGP region (Hill et al., 33.113.070,071; 33.002.067; 34.131.023), SGP region (Degewij, 31.113.089; McFadzean et al., 34.113.023, and Twarog, AJ 89, 523), SA 128 and 156 (Knude, 31.113.090), ten areas at high gal. latitudes (Knude, 29.113.053), open clusters (Stetson, 30.153.024; Schmidt, 31.153.042,047; 32.153.004; 33.153.004; ApJ Suppl. 55, 455; Eggen, 32.153.043; 33.153.005,006,007,009; 33.113.052; Twarog, 33.153.017; Shobbrook, 34.153.031; MNRAS 206, 273; Anthony-Twarog, AJ 89, 655), globular clusters (Richtler and Nelles, 33.154.019; Ardeberg et al., 34.154.039), binary stars (Lindroos, 29.118.024; Olsen, 31.064.100; 31.113.020; Wolf and Kern, 34.119.027), high velocity A stars (Stetson, 30.111.016), white dwarfs (Koester and Weidemann, 31.126.023; Wegner, 33.126.006), metal-deficient giants (Ardeberg and Lindgren, 31.113.096; 32.113.025), RR Lyrae-type stars (Siegel, 31.122.079), Cepheids (Eggen, 34.122.006), hot subdwarfs (Bergeron et al., AJ 89, 374), Ap stars (Manfroid and Renson, 29.113.021; 33.113.021). The Strömgren system was used to classify stars in spectral types and luminosities by Oblak and Chareton (30.114.081) and Westin (Stockholm Rep. 25). The method of photometric boxes was used by Philip and Egret (33.113.055). Intrinsic color indices were discussed by Burkhart and van't Veer (30.113.039) and Shulov (Trudy Leningrad AO, 39, 54). Axial rotation effects were investigated by Schmidt and Forbes (MN 208, 83).

2. The Geneva system. Rufener (30.002.008) has published the third Geneva photometric catalogue, containing 14633 stars. Nicolet (29.113.023; 30.153.028; 31.113.008; 31.002.064) developed the method of photometric boxes for classification of stars. Egret and Heck (Proc. Statistical Methods in Astronomy Symp., Strasbourg, 1983, 149) have presented a progress report of the prediction of MK classification from photometric indices in the Geneva system. The classification of B-type stars was developed by Cramer (32.113.014 and AA 132, 283), the temperature criteria have been discussed by Meylan and Hauck (30.113.038 and IAU Symp. No. 111, Como). The following types of stars were investigated: the nearby stars (Grenon and Rufener, 30.113.017), the nearby open clusters (Hauck, 29.153.042; Golay and Mauron, 31.153.005), Ap stars (North and Cramer, 30.113.031; Cramer and Maeder, 30.113.032; Hauck and North, 32.113.026; Hauck, "The MK Process" workshop; North, AA Suppl. 55, 259), Am stars (Hauck and Lovy, 30.113.035; Nicolet and Cramer, 33.113.008; Nicolet, 33.113.020), variable stars (Rufener and Bartholdi, 31.123.030), β Cephei stars (Waelkens, 29.113.024), metal-deficient giants (Grenon, 31.154.055).

3. The Vilnius system. A number of areas was investigated through two-dimensional photometric classification of stars and determination of their interstellar reddening: the Taurus dark clouds (Straizys, Meištas et al., 29.131.210; 29.131.243; 29.122.046; 30.131.203; 31.114.027; 32.114.021; 32.131.169; 32.131.901), the area of open cluster IC 4996 (Pučinskas, 32.113.063; 32.131.306; Bull. Vilnius Obs. 65), the area of globular cluster M71 (Janulis and Straizys, *Astrophys. Space Sci.* 100, 95; Bull. Vilnius Obs. 67, 18), the area of globular cluster M56 (Smriglio, Boyle, Nandy, Straizys et al.), the Scorpio-Ophiuchus dark cloud (Straizys, Bull. Vilnius Obs. 67, 3), the NGP area (Bartašūtė, Bull. Vilnius Obs. 68, 33). The following types of stars were investigated: metal-deficient giants by Bartkevičius et al. (30.114.161; 32.113.067; Bull. Vilnius Obs. Nos. 63, 66, 68), G-K subdwarfs by Straizys et al. (*Astrophys. Space Sci.*, 104, 219), carbon, zirconium, barium and CH stars by Dzervitis and Paupers (30.113.071,072,075; 34.113.017), Bartkevičius and Šleivyte (Bull. Vilnius Obs. 64, 24) and Šleivyte (Bull. Vilnius Obs. 69), T Tauri-type stars by Meištas (32.121.049). The system was calibrated in terms of spectral types, absolute magnitudes, temperatures and gravities by Straizys et al. (30.113.054; 32.113.064,065).

The Vilnius-Geneva (VilGen) system has been described by Straizys et al. (32.113.066) and North et al. (31.113.018).

4. DDO system. Meylan (31.002.003) has prepared the catalogue of DDO observations of 2911 stars on magnetic tape. Other catalogs of the field giants have been published by McClure and Forrester (30.002.077) and Dean (30.113.080). The system was used to investigate the red giants in open clusters (Janes, 30.153.017; Smith, 31.153.007; 33.153.036; Pastoriza and Ropke, 34.153.041; Claria and Lapasset, 34.153.042; Janes and Smith, *AJ* 89, 487; Schmidt, *ApJ Suppl.* 55, 455), in moving groups (Lü, 31.152.010; Lü and Tsay, 34.152.007; Smith, 32.153.006; 34.152.011), at the Galactic Poles (Hartkopf and Yoss, 32.155.062), red dwarfs (Uppgren et al., 30.113.051), metal-deficient giants (Pastoriza et al., 31.113.088), Cepheids and supergiants (Dean, 30.122.118), barium stars (Lü et al., 33.002.043), RV Tauri and SRd stars (Mantegazza, AA 135, 300), red variables (Bergmann et al., *Astrophys. Space Sci.* 100, 341).

5. Walraven system. The system was used to investigate open clusters (The et al., 31.153.012; Bakker and The, 33.153.015; Verschoor and van Genderen, 34.153.009; Waard et al., AA Suppl. 56, 373), field Cepheids (Coppola et al., 32.122.060), Magellanic cloud Cepheids (van Genderen, 33.122.030, 068; 34.122.014), Magellanic Cloud supergiants (van Genderen et al., 31.113.010; 33.113.007), Ap stars (Deul and van Genderen, 33.113.014; Weiss and Schneider, AA 135, 148), Am, δ Del, δ Sct stars (Wiertz and van Genderen, 33.113.037), metal-deficient giants (Nelles et al., 34.114.122 and AA 139, 220), SGP stars (Trefzger et al., 34.114.121 and Messenger 35, 32).

5. Arizona I3-color system. In the system the following objects were investigated: T Tauri-type stars (Chavarria and de Lara, 32.121.018), Be stars (Alvarez and Schuster, 31.122.225; 32.113.024; 33.113.012,034,059), O-type stars (Schuster, 33.113.032), B-type stars (Schuster, *Rev. Mex. AA* 9, 53).

(c) Narrow-Band Systems

Narrow band H β photometry was used together with medium-band uvby photometric system (see b1 section of this report). The measurements of other hydrogen lines have been published by Ducati (30.002.002; 31.002.041), Claria and Escosteguy (30.113.045), Zeuge (31.115.013), Cester et al. (33.113.064), Mendoza et al. (31.113.045; 33.113.013) have used the α L system to measure the intensities of H α and OI at λ 7774. Maitzen et al. (30.113.020,030; 30.153.004; 32.153.024; 33.113.056; 34.153.012; 34.155.086; AA 138, 189) measured the λ 5200 depression in Ap stars. The gnmfu system was used to investigate G–K type stars at the NGP (Hansen and Radford, 34.113.008) and G dwarfs (Kjaergaard, AA Suppl. 56, 313). The bands of NH, CN, CH, and C₂ in carbon stars were measured by Yorka (34.113.041). TiO bands were measured by Mould et al. (31.113.083; 31.154.100; 32.154.024). Four-color system measuring CaH and TiO bands was used by Jones et al. (29.113.001; 34.002.066). The infrared Wing system was used photographically by Palmer and Wing (32.031.667) for identification of M and carbon stars. Model atmospheres were used to calibrate the Wing system (Johnson et al., 29.064.083; 31.064.099). Wing and Rinsland (31.114.184; 32.113.023; 32.114.114) have investigated the suitability of band strengths in 1–4 μ m region for classification purposes. Frogel, Cohen and collaborators continued to measure the infrared bands of CO and H₂O in globular cluster giants (29.154.032; 30.154.013; 34.154.060), M and carbon stars in the Magellanic Clouds and the Galaxy (30.115.014), and K giants in the Galactic

central bulge (AJ 89, 1536). Elias et al. (32.113.001) have published a list of CO and H₂O band standards. Greenstein (32.126.003 and ApJ 276, 602) continued to use the narrow-band UBGVRI system for white dwarfs. Similar system was used by Weidemann and Koester (AA 132, 195) and Oke et al. (ApJ 281, 276).

VI. CATALOGUES AND ATLASES (C. Jaschek)

The years covered in this report testify a rapid growth in the number of catalogues and atlases. Lists of new catalogues are regularly published in the "Bulletin d'Information du Centre de Données Stellaires", Strasbourg and the "Astronomical Data Center Bulletin NSSC-NASA", Greenbelt.

Spectroscopic data bases were discussed by C. Jaschek in "The MK Process" workshop and data bases for photometry and other parameters by C. Jaschek in IAU Symp. 111, Como. The compilation of photometric data was discussed by Mermilliod (37.002.025). Ševarlic et al. (34.002.061) have provided a bibliography of photographic catalogues of star positions, which list usually some kind of photometric magnitude.

In what follows, catalogues are divided into (A) observing lists and (B) compilations. The note (T) means that the catalogue is available on magnetic tape from one of the data centers. Lists of type (A) are included if they contain more than about one thousand objects. The section "Atlases" includes spectrophotometric atlases.

(a) Catalogues of Type A; Spectroscopic

N. Houk: Michigan catalogue of two-dimensional spectral types for HD stars. Vol. 3. Declinations -40° to -26° (32.002.126). (T)

(b) Catalogues of Type B; Spectroscopic (including lists of standard stars)

A. G. Agayev, O. H. Guseinov: Catalogue of white dwarfs (31.002.012).

C. D. Garmany: Catalog of Galactic O-type stars (34.002.101).

I. N. Glushneva: List of spectrophotometric standards (34.113.009).

P. C. Keenan: Revised MK spectral standards later than G0 (34.114.034).

M. Jaschek, D. Egret: Catalog of stellar groups. Part one: the earlier groups (34.002.079). (T)

G. P. McCook, E. M. Sion: A catalogue of spectroscopically identified white dwarfs (37.002.084).

A. Bartkevičius, J. Šleivyte: CH and metal-deficient barium stars and their color excesses, Bull. Vilnius Obs. No. 64, 24, 1983.

A. Bartkevičius: Metal-deficient giants in the Galactic field. Catalogue and some physical parameters, Bull. Vilnius Obs. No. 66, 1984.

A. Bartkevičius: Catalogue of metal-deficient F–M stars. Part I. Stars classified spectroscopically. Supplement 1, Bull. Vilnius Obs. No. 68, 1984.

(c) Catalogues of Type A; Photometric

J. Dachs et al.: UVB–H β photometry of luminous stars between $l = 335^{\circ}$ and $l = 6^{\circ}$ (32.113.031).

J. R. Pier: Stars of spectral types A and B in the southern galactic halo. I. UVB photometry (32.113.046).

P. R. Wesselius et al.: ANS ultraviolet photometry, catalogue of point sources (32.002.001). (T)

T. N. G. Westin: Four colour and H β photometry of O–A0 stars in three regions near the galactic equator (32.113.003).

D. Wiedemann: RGU photometrie eines Sternfeldes in $+23^{\circ}$ galaktischer Breite in Richtung zum galaktischen Zentrum (32.113.018).

J. D. Fernie: New UBVRI photometry of 900 supergiants (33.113.042).

G. Hill et al.: Further observations of A and F stars in the region of the North Galactic Pole. IV. A catalogue of uvby β photometry and derived quantities (33.002.067).

I. A. Dubyago: Catalogue of magnitudes and colour indices of 2220 stars in Cygnus (37.113.053).

E. H. Olsen: Four colour uvby and H β photometry of A5 to G0 stars brighter than 8^m3 (34.002.029). (T)

E. H. Olsen, C. L. Perry: A catalogue of H β photometry of southern A5 to G0 stars brighter than 8^m3 (37.111.035). (T)

K. Loden: Photometry in the uvby β system in some galactic regions (B-type stars; 6^m5–10^m2; 1700) (in preparation)

A. Pučinskas: Photographic photometry of stars in the region of open cluster IC 4996 in the Vilnius photometric system (32.113.063).

(d) Catalogues of Type B; Photometric

J. Ducati: A catalogue of observations in Ha (30.002.002). (T)

M. Grenon, F. Rufener: The colours, magnitudes and parallaxes of the nearby stars (30.113.017). (T)

R. D. McClure, W. T. Forrester: A catalogue of homogeneous photometry of bright stars on the DDO system (30.002.077). (T)

F. Rufener: Third catalogue of stars measured in the Geneva Observatory photometric system (30.002.008). (T)

J. C. Mermilliod: UBV data (1976–1982): a complete supplement to the general catalogue (34.002.121). (T)

D. Y. Gezari et al.: Catalog of infrared observations (37.002.079). (T)

(e) Atlases (including spectrophotometry)

I. N. Glushneva (ed.): Spectrophotometry of bright stars (33.003.123).

R. F. Wing, K. G. Carpenter, G. M. Wahlgren: Atlas of high resolution IUE spectra of late-type stars, 2500–3230 Å (34.002.086).

E. A. Barsukova et al.: An atlas of the spectra of early supergiants. I. Procedure and its application to the spectra of eight O9.5–A2.5 supergiants in the range $\lambda\lambda$ 3819–4927 Å (37.114.099)

A. Heck, D. Egret, M. Jaschek, C. Jaschek: IUE low-dispersion spectra reference atlas. Part I. Normal stars (37.002.045). (T)

N. Houk: A second atlas of objective-prism spectra (37.002.088).

S. T. Ridgway et al.: An atlas of late-type stellar spectra 2400–2778 inverse centimeters (37.114.055).

C.-C. Wu et al.: The IUE ultraviolet spectral atlas (37.002.048).

N. S. Komarov et al.: Spectrophotometry of stars in λ 550–900 nm, Kiev, 1983.

J. E. Gunn and L. L. Stryker: Stellar spectrophotometric atlas, λ 3130–10800 Å (33.002.042). (T)

G. H. Jacoby et al.: A library of stellar spectra, *Astrophys. J. Suppl.* 56, 257, 1984. (T)

(f) Miscellaneous

G. Cayrel de Strobel et al.: A catalogue of [Fe/H] determinations (30.002.001).

D. Hoffleit, C. Jaschek: The bright star catalogue. Fourth revised edition (31.002.077). (T)

A. N. Argue: A catalogue of photometric sequences (suppl. 3) (33.002.029). (T)

A. Fernandez et al.: The first dictionary of the nomenclature of celestial objects (solar system excluded) (33.002.035).

D. Hoffleit et al.: A supplement to the Bright Star Catalogue ($m \leq 7.01$) (37.002.007). (T)

M. S. Kazanasmas et al.: Atlas and catalogue of photoelectric standards in stellar areas, Kiev, 1981. (30.002.076).

M. S. Kazanasmas et al.: Atlas of photometric standards in stellar areas, Kiev, 1982. (33.002.011).

V. STRAIŽYS
President of the Commission