29. STELLAR SPECTRA (SPECTRES STELLAIRES)

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In the triennium under review, from the second half of 1984 to the first half of 1987, Commission 29 has sponsored or cosponsored the following IAU Conferences: Symp. 120, "Astrochemistry", GOA, India, December 1985; Symp. 122, "Circumstellar Matter", Heidelberg FRG, June 1986; Symp. 132, "The impact of very high S/N Spectroscopy on Stellar Physics", Paris, France, June-July 1987; Symp.123, "Advances in Helio and Asteroseismology", Aarhus, Denmark, July 1986; Coll. 87, "Hydrogen Deficient Stars and Related Objects", Bangclore, India, December 1985; Coll. 88, "Stellar Radial Velocities", Schenectady, N.Y., U.S.A., October 1984; Coll. 90, "Upper Main Sequence Stars with Anomalous Abundances", Crimea, May 1985; Coll. 92, "Physics of Be Stars", Boukder, CO, U.S.A., August 1986; Coll. 94, "Physics of Formation of FeII Lines Outside LTE", Capry, Italy, July 1986; Coll. 95, "Second Conference on Faint Blue Stars", Tucson, AZ, U.S.A., June 1987; Coll. 102, "UV and X Ray Spectroscopy of Astrophysical and Laboratory Plasmas", Beaulieu-sur-Mer, France, September 1987; Coll. 108, "Atmospheric Diagnostic of Stellar Evolution: Chemical Peculiarities, Mass Loss and Explosion", Tokyo, Japan, September 1987.

This report is a common effort by experts in various fields of stellar spectroscopy.

Short reports on the activity of the four working groups (WG) sponsored by Com. 29 and prepared by their chairmen are also included.

A list of abbreviations is given at the end of this report.

1. O, Of, and WOLF-Rayet stars. (by P.S. Conti)

Several detailed reviews concerning these stars have appeared recently: a monograph viewing the entire field has been completed by Conti and Underhill (NASA SP - in press). Chiosi and Maeder (Ann Rev 24, 329) have discussed the evolution of massive stars with mass loss; the problems of WOLF-Rayet stars have been considered by Abbott and Conti (Ann Rev 25, 113), and by Underhill, summarizing her rather different views (Pub Asp 98, 897). An IAU Symposium on luminous stars and associations in galaxies has also appeared (De Loore, Willis and Laskarides, eds.; Reidel 1986). I will give here a personalized overview of what I consider the most important developments and issues at the present time. The reviews listed above contain more details and very complete references.
The stellar parameters of luminosity, effective temperature, mass and composition are now relatively well understood for the O and Of stars in broad outline, but additional data on the masses from well studied binary systems would be most welcome. Spectroscopic studies with high signal to noise of selected O and Of stars are now possible, given the increased detector quantum efficiencies, and groups in Boulder and Munich have been taking the lead in these efforts. For example, Bohannan et al. (ApJ 308, 728) have analysed the atmosphere of ζ Pup, a well known Of star, and have found an enhanced helium abundance. Their continuing work (in progress) has also revealed enhanced helium for α Cam (but not for either of the O supergiants in the belt of Orion). This careful work suggests that at least some O stars, including (all?) those already identified as Of, are already turning back

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towards the hotter part of the HR diagram, as predicted by the newest models of stellar evolution.

The effective temperature of W-R stars remains controversial although most investigators now feel the values are somewhat higher than had been inferred in the past from continuum studies. Hummer et al. (ApJ in press) have shown that such methods are inadequate to determine stellar temperatures since the emergent continua above the Lyman limit are all similar for these very hot stars. They are able to reproduce the continuum of ζ Pup with a range of model effective temperatures, although only one of which will also give the observed line spectrum.

W-R stars have abundance anomalies as seen in their emission line spectra. These represent stars with their upper layers stripped away so the results of nuclear fusion in the stellar cores are visible. Hillier (ApJ in press) has completed a detailed analysis of the WN5 star HD 50896 in which the inferred abundances of carbon and nitrogen are close to that predicted by highly evolved stellar models. Using detailed models for the stellar wind, he also finds a relatively hot effective temperature for this object, similar to what would be expected for a helium burning core (ApJ Supp 63, 948 and 965).

Pollock (ApJ 320, 283) has discussed the X-ray emission detected with the IPC on the Einstein satellite for 48 W-R stars. Their X-ray luminosities cover a range of 2 ordres of magnitude; some of the X-ray brightest objects also have evidence of non-thermal radio emission. The source of the X-ray flux is probably similar to that in the Ob stars, namely shocks in their winds (e.g. Owocki and Rybicki ApJ 299, 265). Infrared photometry of 41 W-R stars have been given by Williams et al. (AA in press). Circumstellar dust emission is inferred about half the sample, primarily those of late WC subtype.

Detailed models of the winds of O type stars in the Magellanic Clouds has been presented by Kudritzki et al. (AA 173, 293). These incorporate the lower abundances believed to obtain for the stars; they predict lower terminal velocities and mass loss rates. The former prediction seems to be confirmed by observations but the mass loss rates do not seem to scale this way (Garmany and Fitzpatrick ApJ 1988 submitted). The stellar winds of the hot stars of M31 seem to be inordinately weak according to preliminary optical and IUE data presented by Hutchings et al. (ApJ 1987 in press). The normally strong CIV and NV Resonance lines are weak in the handful of stars so far observed in this galaxy. It is not clear whether this is a result of sampling only the brightest stars, which are often pathological, or whether it represents some fundamental new result concerning hot stars in SB type galaxies.

Discovery of new W-R candidates in M31 has been carried out by Massey et al. (AJ. 92, 1303) and Moffat and Shara (ApJ 320, 266). Massey and associates also discussed the Ob star population of several associations in M31 using CCD photometry, finding relatively massive stars in those groups that also contained W-R stars. Spectroscopy of W-R stars in this and other local group galaxies has been carried out by Massey et al. (AJ in press). The WN stars in the solar vicinity, the LMC and M33 seem similar, as do the WC stars. Those W-R stars found in the SMC, NGC 6822 and M31 seem to have relatively weak emission lines as if the winds were less energetic but these results are still provisional and will need more data. Late type WC stars have not been found in any locales other than inward from the Sun in our Galaxy. The explanation for this is not settled. Kunth and Schild (AA 169, 71) have identified some additional more distant galaxies with W-R emission features (HeII). There seems to be a correlation between the HeII emission measure and the luminosity of the parent galaxy, which suggests the mass of newly formed stars scales as the mass of the galaxy.

Moffat and Associates (3 papers in press in the ApJ) have carried out a series of polarization studies of W-R stars. The polarization is due to electron scattering in the wind and is variable in a number of cases: in those known W-R plus O type binaries it is periodic and due to the orbital motion and rotation of the star; in some apparently single stars the changes in polarization are random and caused by inhomogeneities in the wind. They also give an ingenious method for deriving the mass loss rate in the binary W-R stars. Questions of variability in the emission line spectrum and in the continua of W-R stars are still unsettled issues but progress has been reported by Lamontagne and Moffat (AJ 94, 1008). They find variability in just about all the stars they have observed. The entire topic of variability is one in which a concerted observational effort will help our understanding of complicated physical phenomena.

Improvements in modelling of high mass stars, with the effects of mass loss and overshooting are continuing, (Maeder AA 173, 247 and 178, 159; and Maeder and Meynet AA 182, 243). Although main sequence mass loss is reasonably well known (to a factor two or so) the question of overshooting is unsettled theoretically. It is estimated empirically by attempting to fit the observed distribution of hot luminous stars in the HRD by adjusting the mixing outside of the convective core. This seems a reasonable approach and does lead to W-R stars with predicted properties in agreement with those observed. The luminous blue variables (LBV) may play a key role in the evolution of the most massive O stars to the W-R phase. Langer and El Eid (AA 167, 265 and 274) and Langer (AA 171, L1) have considered the evolution of very luminous stars and the origin of the different W-R Sub-types. The stellar models still differ in the details but seem to be converging towards consistency in interpretation of the W-R stars as being the helium burning end products of massive star evolution.

B and Be stars (by D. Baade)

The primary track left behind by B–type stars in the literature of the report period once more was one of mass loss and variability – even without the case of Sk −69 202. Percy's contribution to the report of Comm. 27 and the progress reported by Comm. 36 in the treatment of stellar winds therefore contain essential complements of this summary. The available X–ray observatories were, for various reasons, not suited for the study of the weak X–ray flux from single B stars. Most of their B–type targets were therefore in close binaries so that the field is left to Comms. 42 and 44. This approach is partly extended to binaries in general since there is no new evidence that binarity is more important for B stars than for other stars. (References to proceedings, *etc.* are by *Astronomy and Astrophysics Abstracts* numbers where available. Papers that reference other recent work by their author(s) on closely related subjects, are marked by a plus sign "_+". Mentioning of review papers has purposely been kept to a minimum; the relevant ones are easy to spot.)

Be star envelopes. For IRAS, Be stars not unexpectedly proved the most conspicuous among the B–type stars and inspired an ongoing series of papers (*AA*, **176**, 93 _+) by Waters, Coté, and Lamers. The density decreases as $r^{-2.5\pm0.5}$, indicating a slightly accelerated outflow. Mass loss rates are with a simple disk model up to two orders of magnitude higher than inferred from UV resonance lines but agree roughly with earlier analyses of Hα emission lines and ground–based IR data. While the IRAS data *per se* do not constrain the envelope geometry, the existing evidence for equatorial disks was considerably extended by Hayes's (*ApJ (Letters)* **287**, L39 _+) finding that the intrinsic polarization of ω Ori varies at *constant* polarization angle. From the analysis of a major body of Hα profiles Dachs *et al.* (*AA* **159**, 276 _+) also infer flattened enevelopes. A first, though only one–dimensional, interferometric resolution in Hα of the envelope of γ Cas was achieved by Thom *et al.* (*AA* **165**, L13). With the lifetime of *IUE* now approaching 10 years, important long–term studies become possible. Doazan *et al.* (*AA* **182**, L25 _+) discovered in 2 Be stars an association between the still unexplained long–term V/R variability of the Hα emission (but for which Okazaki, 42.064.067, has renewed the interesting model of one–armed oscillations of a cool disk) and the strength of the C IV UV resonance lines. Similarly, *IUE* (Barylak & Doazan *AA* **159**, 65) and *Voyager* (Peters & Polidan in Proc. IAU Coll. **92** *Physics of Be stars*, eds. A. Slettebak and T. Snow, p. 278) observations indicate long–term variations in the far–UV flux of Be stars; a correlation with the appearance of envelope features is possible.

Winds and discrete UV components. The discrete components of UV resonance lines continue to annoy theorists and to challenge observers. Henrichs (in *O, Of and Wolf-Rayet Stars*, eds. P. Conti & A. Underhill, *NASA/CNRS Monograph*) meticulously discusses in particular the variability patterns and the numerous attempts of an explanation. In non-supergiant B stars, discrete components are closely coupled to the Be phenomenon (Henrichs, *op. cit.*) and, there, intimately related to the so-called superions (Marlborough & Peters *ApJ Suppl.* **62**, 875_+, Grady *et al.* *ApJ* **320**, 376) which in O-stars Pauldrach (Ph. D. thesis, Munich) finds to be a non-LTE effect. Hubený *et al.* (*BAI Czech.* **36**, 214) caution against confusions of HVC's with shell lines; but the observed variability and an extension of the analysis beyond a range of a few Å should provide a clear discrimination.

High-quality observations are now also possible of luminous stars in other galaxies. The Heidelberg group (Wolf, Stahl, Leitherer, Zickgraf, Appenzeller) continued their work on luminous blue variables (LBV's) in the LMC and, *e.g.*, observed an outburst in R 127 (*AA* **127**, 49_+), detected extended circumstellar emission line regions in long-slit spectra (*AA* **158**, 371), and discovered R 81 (*AA*, **184**, 193) as the first eclipsing LBV. Kenyon & Gallagher III (*ApJ* **290**, 542) observed massive winds also in LBV's in M31 and M33; in the same galaxies Massey *et al.* (*AJ* **90**, 2239) found low outflow velocities but no P Cygni profiles in several seemingly normal OB supergiants. Garmany and Humphreys (*AJ* **90**, 2009) identified a population of unusually luminous Be stars in the Magellanic Clouds. Polarimetry (Hayes, *ApJ* **289**, 726_+) and optical (Markova *AA* **162**, L3_+) and UV (Lamers *et al.*, *AA* **149**, 29) spectroscopy saw variations in the mass loss of the galactic LBV P Cygni which appear to be due to semi-regularly (~ 50-200 days) ejected shells; van Gent & Lamers (*AA* **158**, 335) attribute the shell ejection to possible nonradial pulsations, and Lamers (*AA* **159**, 90) argues that numerous weak metal lines in the Balmer continuum are the main driving agent of the very dense wind. Finally, Leitherer and Zickgraf (*AA* **174**, 103) report a visually resolved shell around P Cygni.

Pulsations and rapidly variable mass loss. In most OB stars UV mass loss rates associated with non-saturated resonance lines are fairly constant (Prinja & Howarth, *ApJ Suppl.* **61**, 357). However, this does not apply to LBV's and Be stars; and in normal supergiants considerable variability of HVC's, continuum polarization (Hayes *ApJ* **302**, 403) and Hα emission (Baade, in *O, Of and W-R Stars*) signals at least some structural variations. Two conferences (*PASP* **98**, 29-55, and *Instabilities in Luminous Early-type Stars*, eds. H. Lamers & C. de Loore, Reidel) have been devoted to this subject. Polarimetry by Hayes (*ApJ (Letters)* **287**, L39_+) and spectroscopy by Peters (*ApJ (Letters)* **301**, L61) and others of a few Be stars as well as the work on LBVs further strengthen the evidence for the existence of mass loss events. Penrod (41.122.026_+) found new examples of Be outbursts being related to amplitude variations of low-order ($m \approx 2$) nonradial pulsation (NRP) modes. The important clue is probably the ubiquity of such modes in Be stars and their absence in Bn stars (see also 40.112.126, 42.116.004, 42.122.025, and *Physics of Be Stars*). M.A. Smith (*ApJ* **304**, 728_+) continued his work on other nonradially pulsating B stars; at amplitudes near the soundspeed considerable nonlinearities seem to develop. Application of more 'objective' spectroscopic period search techniques to ϵ Per by Gies & Kullavanijaya (preprint) suggests more modes to be present than found before. It remains to be seen if this will reduce some of the former 'oddities'. The same method indepently found multi-periodicity also in a Be star (Baade, in IAU Symp. **132** *The Impact of very High S/N Spectroscopy on Stellar Physics*, eds. G. Cayrel and M. Spite); accordingly the NRP-versus-rotational-modulation discussion (Harmanec *BAI Czech.* **35**, 193; Balona *et al.* *MNRAS* **227**, 123_+) could come closer to a (partial) conclusion. Higher-order ($m \approx 10$) NRP's have also been detected in a few broad-lined B supergiants (Baade, in *O, Of and Wolf-Rayet Stars* _+).

Rotation, binarity and runaways. Abt & Cardona (*ApJ* **285**, 190) and Kogure & Suzuki (*Astr. Sp. Sc.* **127**, 143_+) note a near-complete lack of Be stars with periods below ~ 50 days. If the rapid rotation of Be stars is not a surface phenomenon, this might explain their high specific angular momentum. Slettebak (*ApJ Suppl.* **59**, 769) gives $v \sin i$'s and spectral types for Be stars in 12 open clusters; color-magnitude diagrams do not furnish important evolutionary differences between B and Be stars. Rotation velocities of 53 Be stars have also been determined by Gao & Cao (40.116.058). Ruusalepp (42.116.012_+) and Stoeckley & Buscombe (*MNRAS* **227**, 801) have attempted to separate v and i by the comparison of different lines. With their shape-distorted gravity-darkened models, Carpenter *et al.* (*ApJ* **286**, 741) achieve consistency between the $v \sin i$'s derived from UV and optical lines. – In a thorough study of 36 proposed OB runaway stars Gies & Bolton (*ApJ Suppl.* **61**, 419) find only two binaries with certainty and discuss the origin of the singles.

Magnetic fields and abundances. Except for rather strong diople fields (and the possible first quadrupole: Thompson & Landstreet *ApJ (Letters)* **289**, L9) in stars which furthermore prove to have anomalous surface abundances (*e.g.* Bohlender & Landstreet in IAU Symp. 132) attempts (*e.g.* Barker *et al.* *ApJ* **288**, 741 _+) to detect ordered large-scale magnetic fields have been insuccessful down to the ~100 gauss level which, unfortunately, is still too high to settle the question of major magnetic atmospheric effects. Likewise, abundance analyses of most 'normal' Pop. I stars not known to be magnetic usually did not yield significant deviations from the average (*e.g.*, Ptitsyn & Ryabchikova *Astron Zh.* **63**, 527; Klochkova & Panchuk *Pis'ma Astron. Zh.* **12**, 928; Adelman *AA Suppl.* **64**, 173 _+); interestingly this also includes several stars probably formed above the galactic disk (Keenan *et al.* *AA* **178**, 194 _+). Similarly (but contrasting with analyses of HII regions), from B stars in clusters Gehren *et al.* (in *Production and Distribution of C, N, O Elements*, eds. Danziger *et al.*, ESO, p. 171) find no convincing evidence for a galactic abundance gradient. Wolff & Heasly (*ApJ* **292**, 589) confirm that in comparison with field stars B stars in h and χ Per are helium deficient by one third. CNO processed material is probably seen *in situ* at the surface of supergiants (Lennon & Dufton *AA* **155**, 79) while Michaud *et al.* (*ApJ* **299**, 741 _+) required an interplay between diffusion and mass loss to explain the abundances patterns of some OB subdwarfs. Gerbaldi *et al.* (*AA* **146**, 341) investigated correlations between chemical pecularities on the one hand and variable radial velocity (binarity, but possibly also pulsation), eccentricity and period on the other; they note a lack of peculiar stars with short periods and/or low eccentricity. Massa *et al.* (*ApJ* **287**, 814) attribute anomalously strong winds in some B V stars of NGC 6231 to a suspected carbon overabundance. Kilogauss magnetic fields do have dramatic effects on the wind (*e.g.*, S.N. Shore *et al.* *AJ* **94**, 737 _+) and may in connection with the wind also explain the probably non-thermal radio flux detected in two He-r stars with the VLA (S.A. Drake *et al.*, 40.116.082).

Unclassified. A most curious group of B stars was discovered by Downes (*ApJ* **316**, 763) which generally resemble sdB's but may switch from phases of normal Hα strength to no Hα at all and *vice versa* without other variations having been detected at low spectral resolution.

Line identifications and spectral and photometric calibrations. Rogerson *et al.* (*ApJ Suppl.* **58**, 265 _+) have listed identifications for 2200 UV features in the narrow-lined B0 V star τ Sco. Numerous spectral energy distributions have been published, *e.g.* by Fitzpatrick (*ApJ* **312**, 596) for LMC supergiants and by Goraya (*MNRAS* **222**, 121 _+) and M. Singh (*Astr. Spac. Sci* **120**, 133 _+) for Be stars. Millward & Walker (*ApJ Suppl* **57**, **63**;) and Hill *et al.* (*PASP* **98**, 1186) have established empirical Hγ luminosity calibrations for luminosity classes V–III and supergiants, respectively. New calibrations of various photometric systems have been given by Schuster (*Rev Mex. A. A.* **9**, 53), Balona (*MNRAS* **211**, 973 _+), Kilkenny and Whittet (*MNRAS* **216**, 127), Cramer (*AA* **141**, 215), and Shulov (*Astron. Zh.* **63**, 734). Sekiguchi & Anderson (*AJ* **94**, 129) have presented an improved equivalent width/spectral type/luminosity class relation for the Si IV and C IV UV resonance lines.

A survey of Be stars in the λλ7500–8800 region was published (Andrillat, Jaschek and Jaschek, AA Suppl, in press). About one hundred stars were observed. IRAS excess radiation in Be stars and the behavior of the CaII infrared triplet was analysed (M. Jaschek, Andrillat, C. Jaschek and Egret, AA in press).

3a A, Ap, Am and CP Stars (by J. Jugaku)

The current state of knowledge concerning A, Am, Ap, and related stars was extensively reviewed at IAU Colloquium N°90 held at the Crimean Astrophysical Observatory, USSR, May 13–19, 1985. The proceedings of this meeting were edited by C.R. Cowley, M.M. Dworetsky and C. Megessier and published by Reidel in 1986. Some of the conclusions reached in the Colloquium may be summarized as follows.

The recent availability of ultraviolet spectra of many stars has had a major impact on the study of these objects. Simultaneously, traditional studies of optical spectra have been advanced by data obtained at very high spectral resolution and with high signal-to-noise detectors. It is now clear that the unusual chemistry

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and magnetic structure of these objects have relevance across the broad domain in the H-R diagram from the upper main sequence to horizontal branch stars and white dwarfs. It may be that the majority of A and B stars have non-solar abundances, at least for some elements. (Two of the brightest early A-type stars in the sky, Sirius and Vega, show signatures of chemical peculiarity).

Much of the chemistry of Ap and Am stars is explicable in terms of the diffusive fractionation. However, it has also become clear that the detailed chemistry cannot be understood without consideration of several hydrodynamic and hydromagnetic processes. For example, high mass-loss rates are capable of explaining the λ Bootis stars, while somewhat lower rates may produce the anomalies that appear in Am stars. Additional physical factors that may be important include meridional circulation, magnetic fields, and turbulence. The chemical differentiation is the simplest and most promissing mechanism for explaining the peculiarities of CP stars. However, several other mechanisms can cause abundance anomalies in main sequence A-stars, and it may be reasonable to consider additional processes in order to explain the observational complexity and variety of the chemically peculiar stars. We may ask, for example, what abundance patterns to expect in the case of mass transfer in binary systems? Theoretical discussions of stellar magnetism focused on a global approach in which fossil and dynamo-generated fields were intercompared. General problems with stellar magnetism are not restricted to Ap stars and much has to be learned about hydromagnetic processes that are active during star formation and pre-main sequence phases, as well as during the hydrogen-burning phase. Although many Ap stars have strong magnetic fields, recent advances in Zeeman-effect techniques have demonstrated that only few Hg-Mn stars could have detectable magnetic fields. The standard A0V star Vega has been shown not to have a detectable field (B=-9±19 G). The Hg-Mn stars may become favorable objects in which to study the distinct abundance patterns that manifest themselves in non-magnetic chemically peculiar stars.

Andrillat, Jaschek and Jaschek studied the variability of Ae and A shell stars (Harvard Obs. Publ.7, 193). They also studied the behavior of the Hα line (AA Suppl. 65, 1) in these stars. A survey of 28 northern stars in the photographic region was carried out by M. Jaschek, C. Jaschek and Andrillat (AA Suppl., in press). The infrared behavior of these stars was analysed by means of the IRAS satellite (Jaschek, Jaschek and Egret - AA 158, 325) and some βPic like objects were detected.

A copy of the detailed reference list of papers in the period from the second half of 1984 through the first half of 1987 is available on request from J. Jugaku.

3b Horizontal Branch Stars (HBS) (by J. Jugaku)

The book by Adelman and Leckrone on "Horizontal-branch and UV-bright stars" (ed. A.G.D. Philip, Davis press inc., Schenectady, N.Y.), contains a very comprehensive review of this subject and will be referred as HBUVBS, hereafter). In it, (p.75) the authors made an abundance analysis of the prototype HBS star: HD 109995, using UV and optical spectral regions. Adelman and Hill (MN, 226, 581) also made fine analyses of HD 109995, HD 16817, and HD 64488 based on coadded high-dispersion spectrograms. Using infrared lines Adelman et al. (PASP 98,783) determined oxygen and nitrogen abundances of the above three stars as well as those of the A stars, θ Leo and HR 6559. Klochkova and Panchuk (Astr ZH, 64, 74) determined chemical abundances of 6 stars (HD 2857, 64488, 93329, 105262, HDE 281679, and BD +20 5009) using high-dispersion spectra obtained with the USSR 6-M telescope. Spectra of three proto-type HBS (HD 86986, 109995, 161817) were also obtained with the 6-M telescope by Philip and Lee (HBUVBS, p.57). An LTE analysis of HD 214080 was made by Keenan and Lennon (AA 130, 179) but this star turned out to be an ordinary Pop I star. An analysis of five high-latitude blue stars were made by Kilkenny and Lydon (MN 218, 279). They used 30 A/MM Reticon spectra and UVBY photometry to determine T_{eff} and log g and checked the results by fitting Kurucz models. Hayes (News Lett Astr Soc NY 2, N°9, 13) discussed a method of determining T_{eff} and log g for HBS. The energy distributions of 16 HBS have been measured by Hayes and Philip (IAU Symp 111, p.469). Similarly IUE ultraviolet energy distributions of four field HBS were obtained by Philip et al. (PASP 99, 54). Jaschek et al. (AA152, 439) pointed out that the features at 1600 and 3040 Å in IUE low-resolution spectra are similar to those previously found in λ Boo stars. Peterson (HBUVBS, p.85) summarized the current status of the presence of primordial stellar rotation among HB stars in globular clusters. Philip (HBUVBS p.41) identified a number of field horizontal branch (FHB) A-type stars in areas at high galactic latitude. Radial velocities and line widths are measured for 7 blue HB stars in the globular cluster NGC 288 by Peterson (Ap J 294, L35). The data support the idea that rotation increases the proportion of blue stars on the HB of some intermediate-metallicity clusters.

4. F, G and K stars (by M. Spite)

The F, G, K stars, characterized by temperatures between about 4000 and 7000K, include a large variety of stars at different stages of evolution. Some supergiants are massive stars crossing rapidly this region , but the majority of the F, G, K stars are low mass stars evolving slowly.
Many of these stars are young but some of them are as old as the Galaxy . Therefore, this type of stars is particularly suitable, to study the metal enrichment of the Galaxy. Definite progresses have been made over the last few years in determining the chemical evolution of the Galaxy in particular because efficient detectors and spectrographs became available at the large telescopes.
Because of their low rotation, G and K stars are also very suitable for line-profile studies, evidencing effects of convection, stellar oscillations and magnetic fields.

FIELD STARS (abundances)

Large progresses have been made in the determination of the abundances of the light elements in the old stars.
- Carbon and nitrogen abundances have been determined in a large sample of disk and halo stars from intermediate dispersion spectra by Laird (ApJ.289,556). He found that C/Fe is constant over a wide range of metallicities; the N/Fe ratio is also constant for the majority of the stars indicating that in the halo the nitrogen production has been largely primary. Moreover four halo stars are found with a large N/Fe ratio .
Independently carbon abundance have been measured in 32 halo dwarfs by Tomkin and Lambert (ApJ.302,415). They show that indeed carbon follows iron down to [Fe/H]≈-1.8 , but that at lower metallicities it seems that there is a positive trend in [C/Fe].
-Gratton and Ortolani (AA.169,201) have derived the [O/Fe] ratio in 18 stars of different chemical composition. They confirm a constant overabundance of oxygen in metal-poor stars.
-The ratios of the light metals Na, Mg, Al, Si ... to iron have been studied in particular by Tomkin et al. (ApJ.290,289), Laird (ApJ.303,718), François (AA.160,264 and AA.165,189), Luck and Bond (ApJ.292,559).
The abundance of all these elements relative to iron is constant in the halo stars. But the even elements are overabundant in the halo and the odd elements (at least down to about [Fe/H]≈-2) have a solar ratio relative to iron. As a consequence the odd/even effect is enhanced in the halo stars.

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An isotopic abundance analysis for Mg in disk and halo stars is also reported by Barbuy (AA.151,189) and Lambert (ApJ.304,436) . They confirm an enhancement of the odd/even effect in the metal deficient stars.
An important point is also the discovery of a metal poor star with "r" process overabundances by Sneden and Pilachowski (ApJ.288,L55). In this star the distribution of the heavy elements abundances is consistent with pure r-process neutron synthesis reactions.

FIELD STARS (atmospheric structure)

The fine structure of stellar photospheric convection: the stellar equivalent of solar granulation can be analyzed with the help of high resolution spectroscopy. The study of stellar granulation and the ensuing inhomogeneities on stellar surfaces has considerable potential, not only for analysis of stellar atmospheres, but also in applications for other astrophysical problems. A fair number of stars has now being observed for photospheric line-asymmetries, revealing significant asymmetry changes across the HR-diagram. Detailed line shape observations for several G and K stars are in Dravins (AA 172, 200 and AA 172, 211).
Observations of stellar granulations coupled with two-stream numerical simulations (D.F. Gray and C.G. Toner, PASP 97; 543) have helped us to understand some of the factors, such as the Expanding-Star Effect and the Rotation Effect (D.F. Gray, PASP 98, 319) that mold the line asymmetries of F, G, and K stars. A reversal of the sense of the line asymmetries was discovered in Ib stars (D.F. Gray and C.G. Toner, PASP 98, 499). Conventional granulation is seen for stars cooler than GO Ib, but for hooter stars, a remarkable reversal is found, possibly indicative of upward velocities ≈ 25 km/s in the photosphere. Preliminary evidence points to a granulation boundary in the HR diagram at which these sudden alterations in granulation occur (D.F. Gray 1986 Advances in Space Research 6, 161).
The important development of helio-seismology has yield very important results in these last years, both in Doppler-shifts and broad-band photometry. Fossat tried to detect the same kind of small amplitudes p-modes on solar-type stars. He presented at the IAU Symp.132 results concerning seismology of the stellar cores of Procyon, α Centauri and ϵ Eridani.
The Zeeman effect has been used to detect magnetic fields in F, G and K stars (Marcy ApJ 276, 286). An interesting review paper (L.W. Hartmann and R.W. Noyes, Ann. Rev. Astr. Astrophys. Vol 25) parallels the stellar and solar characteristics of magnetic fields and associated phenomena.
The structure of the FGK giant and supergiant stars is still not completely understood, but some progresses have been made :
Boyarchuk and Lyubimkov (Astrofisika 20,85) have studied the atmosphere of some F supergiants. The analysis of the FeI lines led to lower values of the microturbulent velocities than the lines of FeII or TiII. This discrepancy is explained by deviations from LTE in the degree of ionisation. In the upper layers of a few supergiant stars, supersonic microturbulent velocity is observed.
On the other hand Tsuji (Astrophys. and Sp. Sc.118,227) has shown that in red giant stars radial velocity gradients are larger for stars with larger turbulent velocities. The stellar turbulence may thus have something to do with the differential velocity field in stellar atmosphere.

OPEN CLUSTERS

High resolution spectra of twelve Hyades dwarfs have been analysed by Cayrel et al. (ApJ.146,249) to determine accurate abundances for metals. The temperatures of the stars have been derived from Ha profile. They obtain [Fe/H]=0.1210.03. For two stars with high chromospheric activity they deduce however lower abundances. Diagnostic indices of active chromospheres have been also given by Rose (AJ.89,1238) for 35 Hyades and 31 Pleiades dwarfs from low resolution spectra.

Rose also proposes that active regions affect seriously many of the spectral lines of the stars.

GLOBULAR CLUSTERS

The main problem with the globular clusters is to understand the reason of their inhomogeneity. In M3, Norris and Smith (ApJ.281,255) have shown that variations in the strength of the CN band persist down to the luminosity at which the theory (meridional circulation) predicts that CN variations should originate. Moreover Hesser et al. (ApJ.295,437) have shown that the abundance spread observed in wCen originates near the main sequence. Norris and Pilachowski (ApJ.299,295) from a spectroscopic survey of 5 globular clusters , found a positive correlation between the behaviour of the sodium lines and the abundance of nitrogen.
On the other hand Leep et al. (AJ.91,117) found that some stars in M13 are very oxygen poor.
Spite et al.(AA.168,197) have derived the distribution of the abundances in a star of a globular cluster of the Small Magellanic Cloud. For the first time, lithium has been detected outside of our Galaxy.

THE ABUNDANCE OF LITHIUM IN OUR GALAXY

The high efficiency of the new detectors in the red has allowed a precise study of the abundance of lithium in different objects. Lithium is one of the few elements synthetized during the Big-Bang , but it is very fragile and can be destroyed at high temperature in the deep layers of the atmosphere of the stars.It is supposed to be formed also in novae , in some giant stars, and by cosmic rays (spallation).
The aims of the precise determination of the abundance of lithium is, on one hand the determination of the canonical abundance, and on the other hand, a check of the structure of the atmosphere of the stars.
A/ -A decisive step has been made in our understanding of the destruction of lithium in the atmospheres of the stars owing to the observation of the behaviour of the lithium in the Hyades cluster.
First , Cayrel et al. (ApJ.283,205) studied the decline of the abundance of lithium in the G and K dwarfs. They found from high quality spectra that the abundance of lithium is decreasing more rapidly with decreasing temperature than heretofore realized. The simple models of lithium burning in the convective zone (with or without overshooting) does not agree with the observations.
Second , Boesgaard and Tripicco (ApJ.302,L49) have obtained spectra of F stars in the Hyades showing the existence of an abundance gap of lithium (the Li-chasm) in the F dwarfs of that cluster. There is a remarkable variation of Li/H with stellar surface temperature : stars with Teff near 6600K show Li depletions by factors >100 relative to stars 300K hotter and cooler. An explanation of this "chasm" by diffusion in the F stars was proposed by G.Michaud (ApJ.302,650).
-The abundance of lithium has been observed in some other galactic clusters spanned in age, but younger than the Sun.
The abundance of lithium has been measured in Praesepe by Soderblom and Stauffer (AJ.282,L7), NGC752 by Hobbs and Pilachowski (ApJ.309,L17), M67 by Hobbs and Pilachowski (ApJ.311,L37) and Spite et al. (AA.171,L8). All the authors deduce that in these clusters the initial abundance of lithium is about the same as in the Hyades.
On the other hand in NGC7789 Sneden and Pilachowski (ApJ.301,860) have shown that some of the "lithium rich" giants have a very low 12C/13C ratio (a signature of mixing). Therefore, the surface lithium in these giants has not survived simply, through a lack of convective envelope mixing.
B/In the field stars the abundance of Li has been measured in some more stars of different types:
Pop.I dwarfs (Soderblom, PASP.97,54; Boesgaard and Tripicco (ApJ.303,724), Pop.I

giants (Smith and Lambert ApJ.303,226), Pop.II dwarfs (Spite et al. AA.141,56 and Spite and Spite AA163,140). Moreover the ratio $^{6}Li/^{7}Li$ could be obtained for several F and G stars (Andersen et al. AA, 136, 65; Hobbs, ApJ, 290, 284; Rebolo et al. AA, 166, 195).

5 M, S, C Stars. (by D.L. Lambert)

Warning! What follows is a personal selection of the many results that deserve the label "recent highlights of spectroscopic investigations of giants and dwarfs of spectral types M, S, and C and the intermediate classes SC and CS; this contribution is NOT a comprehensive summary of work reported since 1984. The reader is urged to consult *Astronomy and Astrophysics Abstracts* and to read some of the many review papers on the atmospheres, internal structure and evolution of these stars.

5.1 **Chemical Composition of Giants.** At last, abundance analyses are being reported for M, S and C stars with a completeness approaching that attained for G and K stars. Three factors might be identified as responsible for this happy development:
(i) Fourier spectroscopy at KPNO and CFHT has provided access to diatomic molecules (e.g., C_2, CH, CN, CO, OH, NH, H_2) in the relatively uncrowded infrared windows. These molecules provide the elemental and isotopic C, N, and O abundances that are tracers of H and He burning in interior layers. (ii) Near-infrared spectroscopy with silicon diode arrays provides atomic lines in windows between the strong molecular bands such as TiO in the M giants. These lines provide the metallicity [Fe/H] as well as abundances of s-process products of He-burning. (iii) Analyses of these spectra and others of crowded regions containing specific lines (e.g. the TcI resonance lines near 4260 Å and the Li I doublet at 6707 Å) are greatly facilitated by development of model atmospheres and spectrum synthesis techniques.
Investigations of elemental and isotopic C, N, and O abundances shows that, as predicted, the first dredge-up has rearranged the abundances: C is depleted and N enhanced (Smith and Lambert, ApJ 294, 326 and ApJ 311, 843, here SL; Tsuji, ApJ 118, 227, and Astr. Ap., 156, 8). The oxygen isotopes ^{17}O and ^{18}O were studied by Tsuji (above, and 1985 in *Cool Stars with Excesses of Heavy Elements*, p. 295) and Harris and colleagues (ApJ 285, 674; ApJ 299, 375, here HLS): the ^{17}O abundances appears to depend on the stellar mass and reconciliation of the observed and predicted ^{18}O abundances was possible when the adopted ^{18}O (p,α) rate was reduced on remeasurement in the laboratory.
The MS and S stars have been shown, as long expected from convincing arguments involving the dissociation equilibrium of TiO, ZrO, etc. for mixtures with $C/O \lesssim 1$, a higher C/O ratio than the M giants. Abundances of s-process products are enhanced. With the use of line blanketed model atmospheres, the M, MS, S stars are shown to have near solar metallicities (see SL). The reported compositions suggest that products of the He-burning shell (nearly pure ^{12}C plus s-process elements) are mixed to the surface of these low mass ($M \leqslant 3 M_{\odot}$) of MS, S, (and C) stars. These observations challenge the theoreticians to produce satisfactory models of low-mass thermally-pulsing AGB stars.
Using Fourier spectra, the CNO analyses were extended to a sample of cool carbon stars (Lambert et al., ApJ Suppl., 62, 373; Harris et al., ApJ 316, 294). A majority of the C stars show a surprisingly modest C enrichment ($C/O \leqslant 1.1$). The $^{12}C/O$ and the high $^{12}C/^{13}C$ ratios are consistent with the addition of pure ^{12}C to the envelope. Fourier spectra of SC stars were analysed by Dominy and colleagues (ApJ 300, 325; ApJ 317, 810). The CNO abundances generally resemble those of the S and C stars. A key remaining problem is provided by the high $^{16}O/^{17}O$ and $^{16}O/^{18}O$ ratios in the M, S, and C stars (see HLS).

5.2 **Atmospheric Structure** Fourier spectra have been used also to investigate atmospheric structure and velocity fields. Hinkle, Scharlach and Hall (ApJ Suppl., 56, 1) extended their earlier work on time series analysis of Miras to nine additional stars. These observations provide extensive information on the Mira atmosphere throughout the pulsation cycle. Wallerstein et al. (P.A.S.P., 96, 222) report similar data for the S star R Cyg. Dominy, Wallerstein, and Suntzeff (M.N.R.A.S., 212, 671) discuss the line doubling seen in infrared CO and visual and infrared atomic lines of V Cnc about 1 month after maximum light. Tsuji (1987, in *Circumstellar Matter*, in press) finds evidence in high resolution CO line profiles for a quasi-static turbulent layer above the stellar photosphere.

5.3 **Winds and Shells** Stellar spectroscopy across the spectrum is providing new insights into the structure of stellar winds and circumstellar shells of cool giants and giants. The selected highlights illustrate this claim. Mutilation of the 2800 Å Mg II chromospheric emission lines by Mn I and Fe I absorption provides evidence for a turbulent layer between the photosphere and the circumstellar expanding shell of the cool carbon star TX Psc (Eriksson et al., Astr. Ap., **161**, 305). The circumstellar gas around cool evolved stars is detectable by resonance line scattering of photospheric radiation. Mauron et al. (Astr. Ap., **165**, L9) provide an image of the extensive shell around the M supergiant μ Cep. Sahai and Wannier (ApJ, **299**, 424) used a Fourier spectrometer to detect resonantly scattered CO vibration-rotation emission lines at 4.6 μm from different regions of the shell around the shrouded carbon star IRC+10216, and constructed a model of the inner envelope. As 2D arrays in the visible and infrared are exploited more fully, spatially resolved spectroscopy is sure to reveal more of the secrets of stellar winds, shells, and the mass loss experienced by AGB stars. With new telescopes and more sensitive arrays, the triennium has seen new observations at millimeter and radio wavelengths of the molecular line emission from shells (e.g., Knapp, ApJ, **293**, 273; ApJ, **311**, 731). The maximum mass loss rates are close to the maximum predicted for a wind driven by radiation pressure on the mass in the wind (here, the dust) - see Jura (ApJ, **275** 681), and Knapp and Morris (ApJ, **292**, 640). With the implementation of mm-wave interferometers, the spatial structure of the line emitting shell is being mapped (Masson 1987, in *Late Stages od Stellar Evolution*, p. 119).

5.4 **Magellanic Clouds** No report on the spectroscopy of M, S, and C AGB stars would be a fair reflection of recent progress without a mention of the Magellanic Clouds and other distant ensembles of stars (e.g., the Galactic bulge). Through low resolution spectroscopy and photometry of LMC and SMC stars, many clues have been provided to the evolution and structure of AGB stars -see, for example, reviews by Wood (1987, in *Late Stages of Stellar Evolution*, p. 197; and 1987, in *Stellar Pulsation*, p. 250). Results include one period-luminosity law for low mass LPVs and another for high mass/supergiant LPV, and a proposal that stars above the mass M_{up} ($\lesssim 3M_{\odot}$, perhaps) may shed their envelopes before the thermal pulses convert them from O-rich to C-rich. I expect these pioneering studies to continue and to be supplemented by high resolution spectroscopy of the brightest stars in the Magellanic Clouds and the Galactic bulge where metallicities as high as [Fe/H]≈1 have been proposed from analyses of low resolution spectra of K giants (Whitford and Rich, ApJ, **274**, 723).

5.5 **Cool dwarfs** To conclude, I offer two comments on the spectroscopy of the cool dwarfs. One exciting development has been the observation of Zeeman split line profiles in infrared spectra of AD Leo, an M dwarf flare star (Saar and Linsky, ApJ, 299, L47). The clear resolution of the Zeeman components of Ti I lines is indubitable evidence for a strong field ($H \approx 3000$ to 4000 G). The interested onlooker may not have been convinced by earlier evidence for fields in various dwarfs and giants that was based on rather subtle broadenings of line profiles in

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the visible and near-infrared.
Since the tools have just become available, one expects to see M dwarfs subjected to detailed abundance and structural analyses. Analyses of pop. II dwarfs may yield novel data not readily provided by the warmer dwarfs; the molecular lines may provide critical isotopic ratios. Undoubtedly, peculiar stars will be discovered. However, few, if any, will rival the dwarf carbon star G77-61. Recent work shows that it is binary with an unseen companion (Dearborn et al., ApJ, 300, 314) and that the star is very C-rich but extremely metal-poor: [Fe/H]≃-5.6 is proposed by Gass, Liebert, and Wehrse (1987, preprint).

6. Pre-main-sequence Stars (by J. Krautter and R. Mundt)

In the period covered by this report (1984-1987) the number of outflow sources found increased enormously. This threw new light on our understanding of the star formation process, since mass outflow is now considered to be a very common and important phase in the evolution of low- and intermediate-mass stars. This development was - at least in part - only possible because of further improvements of spectrographs and detectors. Another sign of this period is the increasing number of publications based on simultaneous observations in different wavelength regimes.
The proceedings of the following meetings contain reviews and many original papers on the spectra of PMS stars: "Nearby Molecular Clouds", Toulouse 1984, Lecture Notes in Physics 237; "Protostars and Planets II", Tucson 1984; IAU Symposium no.115, "Star Forming Regions", Tokyo 1985; and IAU Symposium no.122, "Circumstellar Matter", Heidelberg 1986.

6.1 T Tauri Stars.

Recent reviews concerning spectroscopic aspects of T Tauri stars were given by Cohen (Phys Rep 116, 173), Herbig (Birth and infancy of stars, 535), Appenzeller (Phys Scr T11, 76), and Herbst (PASP 98, 1088).
Spectroscopic surveys in order to find new T Tauri stars were carried out by Herbig et al. (AJ 91, 575), Wiramihardja et al. (Stellar activities and observational techniques, 137), and Wilking et al. (AJ 94, 106).
Petterson (AA 171, 101) presented many detailed observations of hitherto unknown T Tauri stars in the Gum nebula, Whittet et al. (MNRAS 224, 497) studied the Chamaeleon T-association. Spectroscopic observations of a larger sample of T Tauri stars were carried out by Rydgren et al. (Publ US Naval Obs, 2nd ser., Vol. 25, 114) and Sun et al. (AA Supp. 62, 309).
Grinin et al. (1985, Astroph 22; 1985, Bull Crim Aph Obs 71, 111), Ismailov and Rustamov (1987, Sov Astron Lett 13), and Walker (PASP 99, 392) studied the variability of emission lines and continuum in several stars in Taurus and Auriga. High resolution spectra (R 2 x 10^4) were used by Appenzeller et al., (AA Supp 64, 65) to derive the basic properties of the different types of emission lines and of the photospheric absorption spectrum in the stars S CrA and GQ Lup. They explain the differences in the two spectra with the same physical model seen under different inclination angles. Kolitov (Sov Astron Lett 12) found strong Hα emission in LHα 324, contrary to earlier publications, where no Hα emission had been reported. Emission line widths were used by Saal. (MNRAS 222, 213) to study the flow velocities in the winds of T Tauri stars. A list of 520 absorption lines in the spectrum of T Tauri is given by Korutin and Krasnobatsev (1986, Bull Crimean Ap Obs 75). Physical properties of AS 353 A were determined by Böhm and Raga (PASP 99, 265). Boesgaard (AJ 89, 1635) found from high-resolution spectroscopy of RU Lup significant changes of emission line profiles and intensities within a few days. Giovanelli et al. (ESA SP 263, 95) report on X-ray, ultraviolet, optical, infrared and ratio simultaneous observations of RU Lup from 1983-1986. Strong variations on different time scales were detected in all the wavelength regions, both in the line intensities and in continuum.

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Many papers deal with UV observations of T Tauri carried out with the IUE satellite. Review papers were given by Imhoff (NASA CP 2349, 81) and Giampapa and Imhoff (Protostars and Planets II, 386). The UV properties of PMS objects in general were reviewed by Imhoff and Appenzeller (Exploring the Universe with the IUE Sat, 295). Brown et al. (1984, NASA CP 2349, 338) present high- and low-resolution IUE spectra of RU Lup. Strong P Cygni profiles are observed. They derive a transition region density of $3x10^{10}$ cm^{-3} and discuss the status of the atmospheric modeling.

Further UV results are published by Simon (1984, NASA-CP2349, 183), Calvet et al. (ApJ 293, 575), Brown et al. (1986, ESA-SP 263, 177), de la Reza et al. (1986, ESA-SP 263, 107), and Herbig and Goodrich (ApJ 309, 294). A more theoretical interpretation of the most relevant IUE observational results,is given by Lago et al. (1984, ESA SP-218, 233). The main topics are the presence of high temperature regions around T Tauri stars, stellar winds, and the origin of the continuum and molecular emission.

Finkenzeller and Basri (IAU Symp 122, 103; ApJ, in press) obtained calibrated optical high-resolution and high S/N spectra of 7 T Tauri stars of low to intermediate activity level. They conclude that all important features are clearly chromospheric, and that the physical processes do not differ qualitatively from the ones found in extremely active T Tauri stars. Upper limits to coronal line emission in X-ray detected T Tauri stars were measured and discussed by Lago et al. (MNRAS 212, 151) and Lamzin (1985, Sov Astron 29).

High-resolution spectra do now allow to very accurately measure rotational velocities in T Tauri stars. Hartmann et al. (ApJ 309, 275) confirm that T Tauri stars are generally slow rotators. They do not find a correlation between Hα emission and rotation. Bouvier et al. (AA165, 110) present rotational velocities of 28 T Tauri stars down to a resolution limit of a few km/sec. The lack of very slow rotations (vsini $\leq$ 6 km sec^{-1}) suggests that a minimum rotational velocity may be necessary for the T Tauri phenomenon to turn-on.

Several papers deal with IR spectroscopy. Persson et al. (ApJ 286, 289) studied Bracket-alpha line profiles with a velocity resolution of 45 km/sec of several T Tauri stars and embedded sources. Simon and Cassar (Ap 7283;, 179) use high-resolution spectra in the 2 - 2.4 μm region to study the conditions in the envelope of LHα101. Cohen and Witteborn (ApJ 294, 345) show that silicon emission features around 10 μm are common in T Tauri stars. Thompson (ApJ 312, 784) finds an excess of hydrogen line emission.

Papers concerning more theoretical aspects of the T Tauri spectra and the line formation in the atmospheres and circumstellar envelopes are the review paper on "Theories of mass loss" by Hartmann (Fund Cosmic Phys 11, 279), the model for XUV ionization of He I in the atmospheres of T Tauri stars by Calvet (1984, Rev Mex Astron Astrofis) and Lago's wind model for RU Lup (MNRAS 210, 323).

6.2 **Post-T Tauri stars (PTT).** An increasing number of studies have been carried on these objects since the last report. A large number of potential PTT have been found by analysis of Einstein X-ray data (Walter, ApJ306, 573; Feigelson et al., AJ, in press) and by searches for CaII H+K emission through objective prism surveys (Herbig et al., AJ 91, 575). Spectroscopic studies of these low activity stars have discussed by Walter et al. (ApJ 314, 297). It has been argued by Walter that many of these stars are not PTT but so called "naked" TTS, which are coeval with the TTS; he argues that for some reasons (e.g. lack of an accretion disk) they show a much lower activity then normal TTS. The rotational velocities and kinematic properties of some of these stars has been studied by Hartmann et al. (AJ 93, 907). Several of these PTT show period light variations (Rydgren et al. AJ 89, 1015), which is attributed to spots on their surface.

Spectroscopic and photometric observations of the spotted star RY Lup are reported by Liseau et al. (AA 183, 274).

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6.3 Herbig Ae/Be stars (HBeS). High quality spectra of 27 HBeS are discussed by Finkenzeller and Jankovics (AA Supp 57, 285). The line profiles are discussed and several important quantities (e.g. radial velocities) are derived from the data. Rotational velocities (v sin i), spectral types and the properties of their forbidden lines are derived by Finkenzeller (AA 151, 340). Intermediate mass pre-main sequence stars (Herbig Ae stars) were studied to establish further their properties as a class (Catala et al., AA 154, 103). The star AB Aur revealed short-term variability, with a rotational modulation of the wind velocity at various depths (Praderie et al. Ap. J. 303, 311, Catala et al. Ap. J. 308, 791, Catala et al., AA, 182, 115). Spectroscopic and photometric observations of the star Z CMa and Lk Hα 198 are reported by Covino et al. (AJ 89, 1868) and Chavarria (AA 148, 317), respectively.

6.4 FU Ori object (FUORS). The recent years brought decisive progress in the understanding of these unusual pre-main sequence stars. A number of observational data have been obtained, which strongly suggest that FUORS are surrounded by luminous accretion disks. The outburst is explained by very high mass accretion rate, being caused by an accretion disk instability. This model is based on new optical and IR spectra and is discussed in a series of papers by Hartmann and Kenyon (ApJ 299, 462; ApJ 312, 243; ApJ 322). The outflow source L1551-IRS5 was recognized as a FUOR by Mundt et al. (ApJ Lett 297, L41) on the basis of its optical spectrum. The Hα and NaD line profiles of the brightest FUORS have been discussed by Bastian and Mundt (AA 144, 57) and Crosswell et al. (ApJ 312, 227). A detailed study of the FUOR HH57-IRS has been carried out by Reipurth (AA 143, 435). The ring-shaped nebula of FUORS are discussed by Goodrich (PASP 99, 116). The photometric behaviour and light curve of FU ori and V1057 Cyg in the optical and IR are described by Kolotilov and Petrov (1985, Sov Astr Lett 11(6), 358) and by Kapatskaya (1984, Astrofisika 20, 138).

6.5 Herbig-Haro objects (HHO), optical jets. A strongly increasing number of papers has been published about this topic the last three years. Through intensive CCD imaging many more jets and also HHO have been discovered. It is now generally accepted that HHO and jets are highly related outflow phenomena in star formation regions. Both phenomena are tracing the outflowing matter in these regions with the highest degree of collimation (a few degrees) and with the highest velocity (200-400 km/s). On deep CCD images long-known HHO often turn out to be the brightest parts of a jet or collimated outflow. The following reviews have been published the last three years on this topic: Mundt, Schwartz (1985, in Protostars and Planets II, eds. D.C. Black and M.S. Matthews); Canto, Mundt (1985, in "Nearby Molecular Clouds", Lect. Notes Physics 237), Mundt, Schwartz (1986, Can. J. Phys. 64); Canto (1986, in "Cosmical Gas Dynamics", ed. F.D. Kahn); Staude (Ap Sp Sc 128, 179); Cohen, Dyson, Mundt, Norman (1987, in IAU Symp. 122) Mundt et al. (ApJ 319, 275). A review on molecular outflows and related topics has recently been given by Lada (Ann Rev AA 23, 267).

CCD imaging data and for spectroscopic data on individual HHO and jets have been collected by Axon and Taylor (MN 207, 241),Krautter et al. (AA 133, 169), Lenzen et al. (AA 137, 202), Mundt et al. (AA 140, 17), Brugel et al. (ApJ Lett 287, L93); Böhm and Solf (ApJ 294, 533), Hartigan and Lada (ApJ Supp 59, 383), Walsh and Malin (MN 217, 31), Schwartz et al. (AJ 90, 1820), Bührke et al. (AA 163, 83), Hartigan et al. (AJ 92, 1155), Krautter (AA 161, 195), Strom et al. (ApJ Supp 62, 39), Ray (AA 171, 145), Meaburn and Dyson (MN 225, 863), Solf and Böhm (AJ 93, 1172), Neckel et al. (AA 175, 231).

Recently several HHO have been discussed in terms of radiating bow shocks, created by a rapidly propagating jet or a bullet. Several HHO have been discovered recently, which have indeed a shape very similar to that of a bow shock. The most

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striking example is HH34 (Reipurth et al. 1986), several other examples are discussed by Mundt et al. (ApJ 319, 275). HHO models based on radiative bow shock are discussed by Raga (AJ 92, 637), Raga and Böhm (ApJ 308, 829), and Hartigan et al. (ApJ 316, 323).

7. The Spectra of White Dwarfs (by J. Liebert)

Observational advances in the last several years may be divided into the broad wavelength categories of (1) ultraviolet spectrophotometry, at both low and high resolutions, (2) high precision optical spectrophotometry, as discussed below. Some of the complementary advances in model atmospheres and envelope studies are also mentioned, as they pertain to the observational results. Wehrse, R. (1985, in Reports on Astronomy, Transactions of the IAU, Vol. XIXA, p. 513) recently reviewed the studies of white dwarfs using model atmospheres for Commission 36. A general discussion of the evolution of surface abundances in white dwarfs is included in the review by Sion, E.M. (1986, Publ. Astron. Soc. Pacific, 98, 821). This paper also includes a discussion of the observations of white dwarf primary stars of cataclysmic variables, an exciting subject which is not included here due to space limitations. A comprehensive review of colors and luminosities is given by Eggen, O.J. (1985, Publ. Astron. Soc. Pacific., 97, 1029). Trimble, V. (1986, Q.J.R. Astron. Soc., 27, 38) summarizes the diverse results on low luminosity stars presented at a conference in honor of Prof. J.L. Greenstein. Also worth noting in a more general context is the publication of model atmospheres and emergent fluxes for cool DA and DQ white dwarfs (Galdikas, A. 1985, Vilniaus Astron. Obs. Biul., NR. 72 and 73).

Ultraviolet spectroscopy. The international ultraviolet explorer (IUE) Observatory has permitted white dwarfs to be studied in the ultraviolet (1150-3100 Å) over the last decade, and an impressive list of discoveries and related advances are reviewed in Liebert, J. (1984, "White dwarfs at ultraviolet wavelengths") and in Vauclair and Liebert (1987, in "Exploring the universe with the IUE Satellite", eds. Y. Kondo et al., D. Reidel publishing Co., Dordrecht, p. 355). The unexpected spectroscopic features discovered by the IUE in a variety of white dwarf stars represent the most important contributions. On the other hand, the limitations in both the Sec Vidicon and the aperture have limited the accuracy of the absolute spectrophotometry for estimating the effective temperatures of hot stars. The comparison of IUE temperature determinations with those derived from optical measures have been quite good for several hot DA stars (Holberg, D., Wesemael, V. and Basile, J. ApJ, 306, 629). Wesemael, F., Lamontagne, R. and Fontaine, G. Astron. J. 91, 1376, used IUE data to refine the temperature range of the instability strip of the pulsating ZZ Ceti variables. Less encouraging was the agreement between optical and ultraviolet data fits for the hot DB stars (Liebert et al., ApJ, 309, 241).

The identification of strong, broad absorption features near 1400Å and 1600Å in cool DA (hydrogen atmosphere) white dwarfs was one of the unexpected IUE results. Koester et al. (Astr. Ap., 142, L5) and Nelan, E.P. and Wegner, G. (ApJ Let., 289, L31) independently and simultaneously proposed the explanation that the absorptions are caused by quasi-molecules of H_2 and H_2^+. IUE observations indicate that the features appear in all DA white dwarfs cooler than about 20,000 K. A similarly pervasive set of features in cool white dwarfs with helium-rich atmospheres had also been discovered earlier with the IUE; these are attribute to atomic and molecular carbon. Time-dependent calculations of the dredge-up of trace material from the carbon core offer quantitative agreement with the derived carbon abundances, provided that the helium envelope has a rather small mass (Pelletier et al., ApJ, 307, 242).

Earlier in the decade, metallic line features were identified in high dispersion IUE Echelle spectra of hot DA white dwarfs, principally by F. Bruhweiler, Y. Kondo and collaborators. While the low ionization transitions were generally attributable to the interstellar medium, lines of higher ionization were found which appeared to come from the stellar photospheres, while still others showed modest blueshifts indicative of a selective stellar wind. During the more recent period, theorists have made progress in evaluating these observations. Line profiles and equivalent widths for a large range of heavy element abundances have been presented for a grid of hydrogen-rich atmospheres by Henry, R.B.C., Shipman, H.L. and Wesemael, F., ApJ, Suppl., 57, 145). The study of Morvan, E., Vauclair, G. and Vauclair, S., Astr. Ap., 163, 145, indicates that the theory of radiative acceleration offers a qualitative, if not yet a fully quantitative explanation.

Similar calculations predict more and stronger features in hot, helium-rich white dwarfs, and a nitrogen abundance greater than solar has in fact been found in the 80,000 K do star PG1034+001 (Sion, E.M., Liebert, J. and Wesemael, F, ApJ, 292, 477). More spectacular still are the species found in ultraviolet and optical spectra of the pulsating PG1159-035 stars (Wesemael,F., Green, R.F. and Liebert, J., ApJ Suppl., 58, 379). The O Vi, C IV and He IV transitions appear to link this group to the helium-rich planetary nebula nuclei of the "O Vi" and WC types (Sion, E.M., Liebert, J. and Starrfield, S.G., ApJ292, 471). Surface abundances have not yet been determined, however.

Optical spectrophotometry. CCD detectors have been used to obtain spectra of unprecedented signal-to-noise ratio within the last several years. Greenstein, J.L., ApJ, 304, 334) found numerous weak features in cool white dwarfs, and demonstrated conclusively that the fraction of stars having hydrogen-rich atmospheres drops decisively at T_{eff}<10,000 K. In the optical ultraviolet, image tube spectra especially using photon-counting detectors are still competitive. A somewhat complementary study of a complete sample of hot DA white dwarfs (Fleming, T.A., Liebert, J. and Green, R., ApJ, 308, 176) resulted in a revised determination of the local birthrate of white dwarfs which is now less than half of the commonly accepted formation rates for planetary nebulae nuclei.

Important leaps in the understanding of magnetic white dwarf stars have been possible because of concurrent advances in the quality of theory and observations. The first such star to show both circularly and linearly-polarized light, GRW+70 8247, also exhibits a set of absorption features whose cause has been unclear untill the last few years. That these are due to Zeeman-shifted transitions of hydrogen in the presence of a magnetic field well in excess of 10^8 Gauss had been suggested in earlier papers by J.R.P. Angel and J.L. Greenstein. However, this explanation is now firmly accepted following the precise matching of the absorption features at optical and near-infrared wavelengths with the detailed predictions from two independent sets of theoretical calculations (Greenstein, J.L., Henry, R.J.W. and O'Connell, R.F., ApJ Let., 289, L25; Angel, J.R.P., Liebert, J. and Stockman, H.S., ApJ, 292, 260; Wunner et al., Astr. Ap. 149, 102). Even more spectacular is the analysis of another case, the rotating magnetic degenerate PG1034+234 which appears to have a surface field approaching 10^9 Gauss (Schmidt et al., ApJ309, 218). Also worthy of special note is the discovery of Zeeman-Split emission lines in the apparently single white dwarf GD356 (Greenstein, J.L. and McCarthy, ApJ, 289, 732).

8. Symbiotic stars (by M. Friedjung)

Nearly all who work in the field now agree on a basic binary model for these stars. A compact mass gainer (main sequence star, white dwarf or perhaps even sometimes a neutron star) accretes mass from a cool giant companion either as a result of Roche lobe overflow of the latter, or if this latter star does not fill the lobe by accretion from its wind. This conception is described in two books (Kenyon 1986, and the proceedings of IAU Colloquium n°103, Mikolajewska, Friedjung, Kenyon and Viotti, eds., in press).

Orbits are becoming much better known, especially through the measurements of the absorption lines of the cool component (Garcia 1986, Astron. J. 91, 1400, Garcia and Kenyon, Proc. IAU coll. 103). The radial velocity curve so determined agrees at least in the case of AG Dra with the orbit found from the reflection effect (Leibowitz and Formiginni, Proc. coll. 103).

Symbiotic stars can generally be divided into two classes depending on whether the cool giant is or is not a Mira variable (Whitelock 1987, PASP 99, 573 and Proc. IAU coll. 103). First results by Bensammar et al. (1987 preprint) indicate the power of Fourier Transform spectroscopy in studying the cool component and circumstellar material on the line of sight between the cool component and the observer. Spectral classification of this component is becoming more precise (Kenyon and Fernandez-Castro 1987 preprint). However metal underabundance and other abundance anomalies may disturb classification criteria as for AG Dra (Iijima et al. AA 178, 203). Most symbiotics seem nevertheless to have abundance ratios characteristic of those of normal M giants (Nussbaumer, Proc. IAU coll. 103). IRAS observations studied by Kenyion et al. (AJ 92, 1118) suggest that in some cases the cool but not the hot components are heavily reddened.

Many individual stars have been studied. A detailed investigation of PU Vul, which is probably a symbiotic nova, by Belyakina et al. (1985, Iz. Krym. Astrofiz. Obs. 72, 3) indicates that the active component near maximum had a spectrum indistinguishable from a normal F supergiant, while the cool component had an effective temperature near 2400 K. Much work has been done on R Agr which possesses what appears to be a jet. In a detailed study Kafatos et al. (AJ Suppl. 62, 853) showed that high ionization ultraviolet HeII and NV emission observed with IUE came from the jet; they interpreted their results in the framework of a thick accretion disk model. Viotti et al. (AJ 319 L7) confirmed the last observation; the same region seems also to emit X rays, detected with EXOSAT. Solf and Ulrich (AA 148, 274) studied the nebula of R Agr at high angular and spectral resolution. They interpreted their informations in terms of a double hour-glass structure, the jet being part of the inner hour-glass. High spatial and spectral resolution observations of CH Cyg by Solf (AA 150, 207) showed the presence of very compact nubulosity in 1986 about 1" from the star, and was identified by him with the at least apparently expanding radio jet observed by Taylor et al. (Nature 319, 38) and perhaps also associated with the X-ray emission detected by Leahy and Taylor (AA 176, 262).

Some recurrent novae are now considered to be symbiotic or closely related; they satisfy the definition given above. The 1985 outburst of RS Oph was studied in detail and early results are collected in the proceedings "RS Ophiuchi and the Recurent Nova phenomenon", ed. M.F. Bode (1987). Bode and Kahn (MNRAS Soc. 217, 205) constructed a model involving the interaction of high velocity ejecta with a slow pre-outburst wind. Models of recurrent novae in general as well as RS Oph in particular have been considered by Livio et al. (AJ 308, 736) and by Webbink et al. (AJ 314, 653). Some, such as RS Oph and T Cor Bor, have according to these authors outbursts produced by accretion events.

As far as symbiotic stars in general are concerned, modelling continues. New more rigorous work on colliding wind models (winds coming from each stellar component) by Girard and Willson (AA 183, 247) should be particularly mentioned in this connection.

9. The importance of stellar spectra libraries for studies of galactic evolution (by B. Rocca-Volmerange)

Models of spectral synthesis or galactic evolution need significant samples of stellar spectra, well representative of the stellar population preferentially emitting in the considered wavelength range. Ideal conditions will be obtained when stellar and galactic spectra are observed with the same instrument. When it is possible, the best way is to use publications in litterature. One of the first samples published in visible is the catalogue by Straizys and Sviderskiene (1972, Bull. Vilnius Astr. Obs. 35, 1) from 3000Å to 10000Å with a resolution 50Å, followed more recently, by Gunn and Stryker (ApJ Sup Ser 52, 121) from 3130Å to 10800Å with a resolution 20 and 40Å and Jacoby et al (ApJ Sup Ser 56, 257) from 3510Å to 7427Å with a better resolution of ≃4.5Å.

Recent improvements in spectral synthesis of galaxies as well as in the large field of evolution of distant galaxies are essentially due to the extension of these libraries to far-UV range, in particular the far-UV spectra atlases published from IUE observations (Wu et al, NASA News 22, Heck et al, 1984, ESA SP-1052) are very useful to build libraries of stars connected with the visible. A library of O to M spectral types and two classes of luminosity, in the 1200Å to ≃1μm wavelength range has been built by Rocca-Volmerange et al, AA 104, 177, and Guiderdoni and Rocca-Volmerange, in press, and introduced in evolutionary models of galaxies.

For a long time, performent minimisation procedures fitted observational spectra of galaxies (essentially ellipticals in visible and near-infrared (from Stebbins and Whitford, 1948, ApJ, 108, 413, followed by many authors) with a synthetic spectrum, giving detailed solutions of stellar populations. The strongest default of this method is the lack of unicity (see Peck, ApJ, 238, 79 and references therein). Such a disadvantage is less severe for evolutionary synthesis since the number of solutions is constrained by stellar evolutionary models but it still exists. One way to limit the number of solutions is to extensively obtain a good fit on a larger wavelength range, including UV (and in a next future, IR) stellar emission. Far-UV satellites observed massive young stars (OB stars) as well as hot evolved stars (Horizontal Branch stars, blue stragglers, planetary nebulae, etc...). That was a rich source of data which could be used to analyze stellar populations of HII regions (Rosa et al, AA Sup Ser, 57, 361 and Lequeux et al, AA 103, 305), the far-UV emission of early-type galaxies or many other specific problems. One of the most questionable problem concerning early-type (elliptical or SO) galaxies is the origin of the "so-called UV-excess". It is not the place here to detail the various episodes of this question: It was successively attributed to massive stars or evolved hot stars according to the epoch and the authors. In a recent paper, Rocca-Volmerange and Guiderdoni (AA 15, 22) used stellar spectra of these far-UV libraries to give an interpretation of the emission of early-type galaxies. The comparison of a spectrum of a F8 star with the galactic spectrum of the SO galaxy NGC3115, treated with the same software (IHAP, ESO) as the stellar spectra, concludes to a dominant population of F stars at the assumed turn-off of the galaxy. With an estimated age 3 to 8 Gyrs, the turn-off appears to be younger than assumed by the classical theories of galaxy formation for ellipticals (Larson, MNRAS, 164, 585). Another conclusion attributing the UV-excess to a star formation process, and not to horizontal branch stars, is also proposed from this analysis. This result is confirmed from the synthetic spectrum of Rocca-Volmerange and Guiderdoni, compared to the observed spectrum of M87 (Bertola et al, ApJ Let 237, L65). Unfortunately spectral resolution in galactic spectra is not sufficient to detect spectral features of hot stars; only the Hubble Space Telescope will give us the opportunity to identify these stars in nuclei of early-type galaxies.

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A second (and not the least!) domain of analysis which is also strongly depending on far-UV stellar spectra, is the large field of distant galaxies, in rapid progress since performances of the present and future large telescopes allow to fix-high-redshift and possibly primeval galaxies as preferential objectives. One way to study formation and evolution of such distant galaxies from observations is to stimulate synthetic galaxies, assumed to be template ones, from a model of evolution including stellar population and nebular component and to apply cosmological effects to the synthetic galaxy. The redshifted resulting spectrum will be compared in spectroscopy as well as in photometry (through filters) with observations. For distant galaxies, optical or infrared observations will correspond to far-UV emissivities from stars in the rest frame. This justifies importance and need of far-UV stellar spectra for such studies. A library of 30 stars has been used in the spectrophotometric model of galaxies (Guiderdoni and Rocca-Volmerange, 1987, AA, in press) to analyze and predict magnitudes and colors of galaxies at different redshifts. A comparison of very distant radiogalaxies observed by Djorgovski et al, (1987, ApJ, preprint) with the evolutionary models of Guiderdoni and Rocca-Volmerange, shows, among other results, that a large factor of evolution has to be taken into account justifying to pursue this kind of studies.

In conclusion, we may subline that any model of galactic evolution (spectrophotometric as well as chemical) is essentially based on stellar data. The interest of the far-UV wavelength range for spectral studies as well as extensive developments of detailed stellar spectra in infrared wavelength range has been sublined.

Working Group on Standard Stars (by A. Batten)

During the General Assembly held in Delhi, the Group discussed the question of finding a suitable solar analogue amongst the stars. No completely satisfactory analogue is yet identified.

The principal activity of the group between Assemblies has been the continued distribution twice a year, of the Standard Star Newsletter under the editorship of Prof. Pasinetti. As well as providing a means of keeping members informed about group activities, the Newsletter also carries brief contributions drawing attention to areas in which standard stars are needed or should be further studied. A running bibliography of papers relevant to standard stars recorded 165 items in the six issues since the last General Assembly.

Members of the Group who also belong to Commission 30 have been active in the re-examination of radial-velocity standards undertaken by that Commission. A full account of that work will be found in the report of Commission 30.

Faraggiana reports that a detailed analysis of the spectrum of Procyon is in progress at Trieste Observatory. An atlas of the spectrum from 2030Å to 2371Å, based on observations with IUE and BUSS VIII, has been published (ApJSup 61, 719, 1986). A further atlas covering the region 2600Å - 3200Å is in preparation. Gerbaldi and Faraggiana are examining suitable photographic spectra in the search for a catalogue of Vega.

Working Group on Be Stars (by D. Baade)

For the working group "Be stars" the most noteworthy event of the report period was IAU Colloquium n° 92. *Physics of Be stars* in August 1986 which was co-sponsored by IAU Commissions 29 and 45 and kindly hosted by the Joint Institute of Laboratory Astrophysics at the University of Colorado in Boulder IAU Coll N°92, brought together 101 participants from 17 IAU member countries. The proceedings were edited by A. Slettebak and T.P. Snow and give a fairly complete and up-to-date account of the status of the knowledge and speculations about Be stars. (Another very brief summary has been incorporated into the Section on Be stars of Commission 29's triennal report.) New instruments and long time base lines accumulated with others have further substantiated the evidence that in addition to the defining emission lines there are at least four more domains in which Be stars differ substantially from B stars : UV resonance lines (*i.e., mass loss*), IR excess (*i.e., amount and extent of circumstellar matter*), polarization (*i.e., shape of circumstellar mass distribution*), and photospheric line profile variations (*i.e., nonradial pulsations*). The latter seem to provide the first direct observational evidence that *Be stars* do in fact differ from *B stars* (which in principle of course is a trivial statement because somehow it must be the *stars that do or do not eject an envelope*).

The insights gained from these new observations, intriguing as they may be, have on the other hand also made clear that real progress probably will come only from a) long-term, b) multi-wavelength and c) multi-site observations, ideally a combination of all three. Some attempts in this direction were already undertaken and proved quite successful, but it appears desirable to put them on a somewhat broader basis. The biannual *Be star newsletter* (edited by G.J. Peters and distributed to nearly 125 different places [≠ from number of recipients by the European Southern Observatory) provides the forum for organizing such campaigns and keeping the community updated on the progress made. An important experience with the campaigns carried out has been that applications for observing time seem to be perceived by time allocation committees rather positively when the proposals are put on a broad (but qualified) basis. An important role of the working group will, therefore, be to further back such efforts.

Like in New Delhi in 1985, the working group and by then newly elected Organizing Committee (currently consisting of the undersigned, P.K. Barker, V. Doazan, J.M. Marlborough, G.J. Peters, A. Slettebak, and T.P. Snow) will meet also during the General Assembly in Baltimore. There, the intended brief confrontation of the implications derived from various types of data is hoped to provide another incentive to coordinate also observational efforts from which so far rather conflicting conclusions have been drawn.

Working Group on Ap Stars (by C. Cowley)

The Observatoire de Lausanne hosted a workshop on Elemental Abundance Analyses on 7 - 11 September 1987. The workshop was organized by Adelman (chairman, SOC), Boyarchuk, and Cowley. The hosts were Hauck, Lanz, and North (LOC). The 21 participants from 9 countries compared results of the analyses of digitized spectra of Omicron Peg and Phi Her. The proceedings of the workshop are being prepared for publication by Adelman and Lanz (October 1987).

A. V. Tutukov (Moscow) and G. Michaud (Montreal) are currently planning a meeting on stellar evolution and surface chemistry. It is anticipated that some fraction of this meeting will be devoted to problems of CP stars.
[A meeting of the Ap Working Group is planned for the Baltimore IAU, at which time plans for a future meeting devoted entirely to CP stars will be discussed. Please check the Commission 29 Bulletin Board for information concerning the time and place of this meeting].

Working Group on Peculiar Red Giants (by C. Jaschek and P.C. Keenan)

This working group has published a "Newsletter of chemically peculiar late-type stars" of which N°5 is being published at Strasbourg, and which is distributed in 300 exemplars. IAU Coll. N°106 is being organized at Bloomington, Indiana, in July 1988, on the subject "Evolution of peculiar Red Giant stars".

Abbreviations

AA	Astronomy and Astrophysics
AA Supp	Astronomy and Astrophysics Supplement Series
AJ	Astronomical Journal
Ann Rev Astr Astroph	Annual Review Astronomy and Astrophysics
ApJ	Astrophysical Journal
ApJ Suppl	Astrophysical Journal Supplement Series
Astr Tsirk	Astronomicheskij Tsirkulyar
Astr Zh	Astronomicheskij zhurnal
Astrofiz	Astrofizika
Astrometr Astrofiz	Astrometriya Astrofizika
Astrophys Space Sci	Astrophysics and Space Science
Bull Inf CDS	Bulletin d'Information du Centre de Données Stellaires
Fund Cosmic Phys	Fundamentals of Cosmic Physics
IBVS	Information Bulletin on Variable Stars
Izv Crim	Izvestiya Ordena Trudovogo Krasnogo Znameni Krymskoj Astrofizicheskoj Observatorii
J Astrophys Astron	Journal of Astrophysics and Astronomy of India
Mem Soc Astr It	Memorie della Società Astronomica Italiana
MNRAS	Monthly Notices of the Royal Astronomical Society
PAS Japan	Publications of the Astronomical Society of Japan
PASP	Publications of the Astronomical Society of the Pacific
Perem Zvesdy	Peremennye Zvezdy
Phys Scr	Physica Scripta
Pisma Astr Zh	Pis'ma v Astronomicheskij Zhurnal
QJRAS	Quarterly Journal of the Royal Astronomical Society
Rev Mex Astr Astrofis ...	Revista Maxicana de Astronomia y Astrofisica
Sov Astr	Soviet Astronomy

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