TABLE 2.

Date:	Jan. 17.34	Jan. 19.35	Jan. 20.33	Jan. 22.36
$\bar{\lambda}_1$	6566.0	6565.4	6565.3	6564.7
$\bar{\lambda}_2$	6560.8	6560.9	6560.9	6560.5
$\bar{\lambda}_3$	6553.4	6554.0	6553.4	6552.5
W_1	7.5	7.1	6.8	6.9
W_2	6.6	5.3	5.2	5.0
W_3	8.7	9.7	9.2	8.6
A_2/A_1	1.01	0.98	1.06	1.04
A_3/A_1	0.47	0.41	0.32	0.22
A_1/A	4.81	5.74	6.16	6.04
A_3/A	2.27	2.31	2.10	1.36
B/A	$8.5\ 10^{-3}$	$7.1\ 10^{-3}$	$5.8\ 10^{-3}$	$1.9\ 10^{-3}$
C/A	$-0.9\ 10^{-3}$	$-0.8\ 10^{-3}$	$-1.0\ 10^{-3}$	$-1.0\ 10^{-3}$

unique non-gaussian component: however, the result of the two-component fit looks remarkably good.

Discussion

It is difficult to explain the details of this line evolution by a spherically symmetrical model and, on the other hand, there is evidence for departures, in nova events, from spherical symmetry (e.g. 5, 6). In our case one could imagine that, while most of the nova shell disappeared due to dilution effects, some denser blobs began dominating the Hα emission. The velocity dispersions of the three components are respectively 190, 140 and 250 km/s, and represent their expansion velocities.

Assuming that all blobs have similar sizes, the time scale for the fading of the line emission is inversely proportional to the blob expansion velocity, and in fact component # 3, the broader one, gets dimmer faster than the others. Let us define τ_{12} as the time scale for the fading of the former two components, and τ_3 as that for the latter one; since the decrease of component # 3 relative to the others is 5 days, its absolute time scale is $\tau_3 = 1/(1/5 + 1/\tau_{12})$. Requiring also that time scales are inversely proportional to the components' expansion velocities, τ_{12} and τ_3 can be derived separately as, respectively, 3 and 1.9 day.

Unfortunately we do not possess absolute calibration of our spectra; anyhow, we observed that the continuum was evolving, in those days, as the components # 1 and # 2. But a rough estimate of the continuum evolution can be given by taking the decrease of the visual magnitude: by using visual magnitudes measured during the month of January (7, 8), the average decrease turns out to be 0.35 mag/day, corresponding to a time scale of 3.1 day, in close agreement with our previous derivation.

A decrease in line amplitude can then be ascribed to expansion of condensations in the nova envelope; they have typically a size of $\approx 10^{13}$ cm, much smaller than the envelope size at that time ($\approx 5 \cdot 10^{14}$ cm); since the components are partially blended, they should be confined to the inner regions ($\approx 10^{14}$ cm).

Therefore a way to explain the observed Hα behaviour of Nova Centauri 1986 involves the presence of a non spherical explosion, with the formation of small condensations.

We are indebted to M. Friedjung and E. Oliva for interesting suggestions, and to J.A. de Freitas Pacheco for giving us a copy of his spectra.

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The European Working Group on Chemically Peculiar Stars of the Upper Main Sequence: The First 10 Years

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1. Introduction

A fraction of the B and A type stars have chemical peculiarities (CP). 4 subgroups are recognized: CP1 or Am, CP2 or magnetic Ap (with enhanced Sr, Cr, Eu, Si lines), CP3 (or non-magnetic Ap, with Hg Mn enhanced) and CP4 (B type stars with He peculiarities, a fraction of them appear to be a hot extension of CP2).

For 10 years now, European astronomers interested in the study of CP stars, and more particularly of Ap-Bp (or CP2 to CP4) stars, have gathered their efforts in a working group (WG). Many of the results obtained by members of this WG have been derived from observations obtained at ESO-La Silla. In the *Messenger* No. 34, an overview of the activity of the group during its first five years of existence was given. On the occasion of the 10th anniversary of our WG we want to present a new report on its work with emphasis on those studies carried out during the last five years.

Beside the original research work of the various group members, a *Catalogue of CP-stars* has been compiled by P. Renson. This list was set up after a large critical survey of the literature; it contains more than 6,000 stars, half of which are CP1 (i.e. metallic line) stars. A number of remarks are provided for each star. They concern mainly other designations, misidentifications, duplicity, variability of different parameters (light, spectrum, magnetic field). With this catalogue, which will soon become available through the "Centre des Données Stellaires" (Strasbourg), will also be published a list of bibliographical references established by P. Renson, M. Gerbaldi, F. Catalano and M. Floquet.

2. Variability

Variability in Ap and Bp stars occurs in (at least) two flavours: on the one hand with periods ranging from the order of half a day to several years, on the other hand with short periods of about 4 to 15 minutes. These latter, rapid variations will be discussed in a following section. The former type of variability is ubiquitous among CP2 and CP4 stars, almost all of which undergo periodic variations of their brightness, spectral features and magnetic field. For most of the cases these are well explained by the *Oblique Rotator Model:* the star is regarded as a rigidly rotating body with an essentially dipolar magnetic field, whose axis does not generally coincide with the rotation axis. Surface inhomogeneities likely related to the magnetic structure are responsible for the observed variations, as a result of the changing aspect of the visible stellar hemisphere along the rotational cycle.

However, as will be argued below, it is not yet quite clear whether all the observed "slow" (as opposed to rapid) variations of CP stars can be explained in terms of the Oblique Rotator Model. In particular, some CP3 stars appear to show photometric variability (studied at ESO mainly by Schneider, 1987) with amplitudes generally lower than for CP2 and CP4 stars.

The most convenient way to determine the rotational period is to make precise, multicolour photometric observations. The Strömgren system has been widely used for this purpose, and Geneva photometry has contributed to this effort.

All periods known up to the beginning of 1983 have been gathered in a catalogue published by Catalano and Renson (1984). About 250 stars had a known period at that time. The first supplement has just been published (Catalano and Renson, 1988) and contains further 58 stars, so that more than 10 per cent of all known Ap stars have a known rotational period.

The contribution of the members of the European WG is quite important, since three quarters of the new periods published since 1983 come from them. Of these (representing 41 stars) most of them have been published by North (1984: 5 stars, 1987: 18 stars) and Manfroid and Mathys (1985: 5 stars, 1986: 8 stars). In these statistics we did not include the few CP eclipsing binaries, but added 3 stars not contained in Catalano and Renson (1988). The new periods found since 1983 are presented in the histogram of Figure 1. Compared to the histogram shown in the *Messenger* No. 34, there is an excess of short periods. The scarce appearance of periods shorter than 0.5 days is worth mentioning; only one of them is quite certain. The other three should still be confirmed.

Now, what is the "completeness" of the period determinations? In order to answer this question, we selected all Southern (i.e. with negative declinations) Ap stars with V < 7.1 (which are members of the BS catalogue plus its Supplement) from the general catalogue of Ap and Am stars of Renson (excluding those of peculiarity types Hg, Mn, HgMn and MnHg, which show less or no variability). Figure 2a (top) shows the number of stars with determined periods as a function of Right Ascension. The cross-hatched area concerns the unambiguous periods, the hatched area indicates uncertain or ambiguous periods and white areas are for constant or suspected long period stars, for which no period could yet be found. Figure 2b (bottom) shows the fraction of Ap stars with known periods. From 250 bright stars, 32 per cent have a well-defined period, and this percentage increases to 42 per cent if uncertain or ambiguous periods are included, as well as stars with very long period or no variation. A smaller number of stars that are observable in the southern winter have been sufficiently studied to allow the determination of the period; the contrast is, however, less striking in terms of percentage than of total number, due to the distribution of known Ap stars across the sky.

In addition, the number of periods known for cluster or association members now reaches about 40. This allows to see how the rotation period varies with age, and it seems that it decreases at the exact rate expected from conservation of angular momentum during the stellar evolution on the main sequence.

It is on the other hand noteworthy that among those stars with well-determined periods, by far the largest fraction are CP 2 stars with enhanced Si or CP 4 stars. This is quite certainly a selection effect, since these stars have periods which very rarely are longer than 10 days, in contrast to the CP2's with enhanced Sr, Cr and/or Eu, among which about 25 per cent have periods in excess of 10 days.

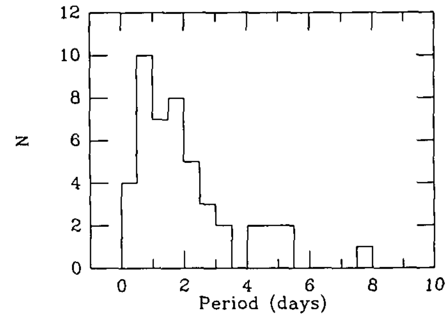

Figure 1: *Histogram of the periods determined since 1983. Some periods are uncertain, especially three of those that are smaller than 0.5 days. Three more stars have periods longer than 10 days.*

Let us now discuss some interesting aspects related to photometric variability. Mathys et al. (1986) present 12 B to early F type stars which proved variable (they were used as comparison stars), and five of them show strictly periodic variations which are reminiscent of CP stars. Their spectral type, however, is not known to be peculiar, although all have an MK classification (four of them are in the *Bright Star Catalogue*). One of these stars (HD 90994) is even a primary standard for MK classification! It is very interesting to note that three of these

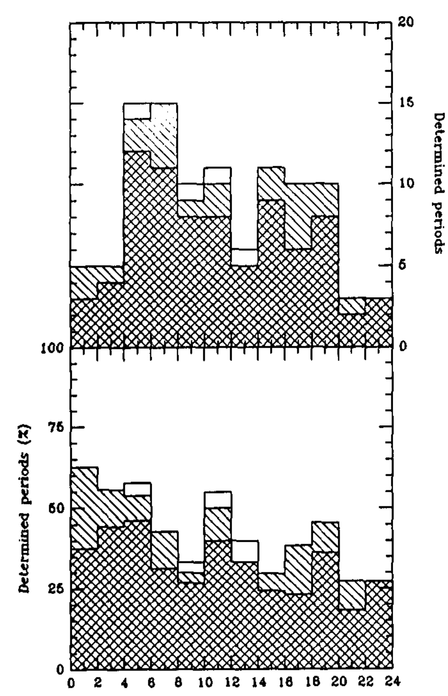

Figure 2a *(top): Histogram of the periods determined up to now for bright non-HgMnAp stars as a function of right ascension. Cross-hatched area: well-defined periods. Hatched area: uncertain or ambiguous periods. Blank areas: stars for which no variation could be found.*
2b *(bottom): Percentage of bright Ap stars with known period (compared to the total number of known bright Ap stars) as a function of right ascension. Same code as in 2a.*

five stars have a rather early spectral type, i.e. B6V, and that all five stars have periods smaller than 3 days, apart from one (uncertain!) exception. This implies that, although the periods and lightcurves of these stars resemble those of classical CP stars, their properties are equally, and perhaps even more, reminiscent of the so-called variable mid-B type stars, discussed by Waelkens and Rufener (1985) as probably being non-radial pulsators, like the 53 Per variables. The lack of any *photometric* peculiarity (indicated by Maitzens's Δa or Geneva $\Delta(V1-G)$ parameters) would tend to confirm this analogy, as well as the fact that Waelkens and Rufener (1985) considered HD 74560 as typical "mid-B variable" while it is a B4pMgSi star. The photometric variations of the latter star would undoubtedly have been interpreted in the framework of the Oblique Rotator Model by an Ap specialist!

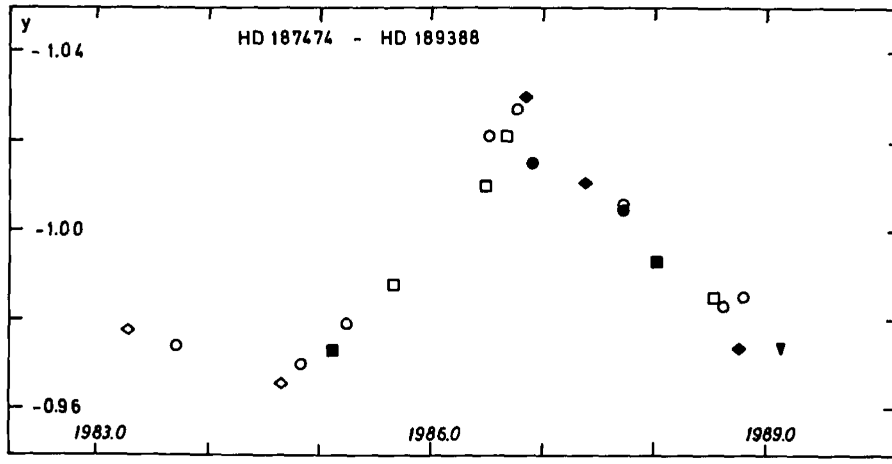

Figure 3: *Lightcurve of HD 187474 in Strömgren y. Open symbols refer to LTPV-group observations, closed symbols to older observations that have been shifted by 6.3 or 12.6 years. Different shaped symbols refer to the telescope + photometric system: ESO 50-cm (circle), Danish 50-cm (square), Bochum 60-cm (diamond), all at La Silla, and CTIO 1-m (triangle).*

Similarly, it can be questioned whether the variability of Hg Mn Bp stars should not be attributed to non-radial pulsations rather than explained by the Oblique Rotator Model.

Another interesting feature in the progress made since 1983 is the quantitative description of the lightcurves. North (1984) has shown that practically all lightcurves of CP stars can be satisfactorily represented by a sinusoid and its first harmonic. This was confirmed by Mathys and Manfroid (1985), who presented a large, homogeneous sample of *uvby* lightcurves for 56 stars and listed the fitted Fourier coefficients. The fact that no higher frequency is needed to represent these lightcurves suggests that there are only two important *spots* (or, conversely, a unique *ring*) with anomalous abundances *on the surface* of Ap stars.

A few especially interesting stars should still be mentioned. The long period star HD 187474 has been monitored in Strömgren photometry, in the framework of the long-term photometric programme of the Sterken group at ESO. Figure 3 shows the visual lightcurve of this star which is a famous spectrum and magnetic variable with a period of about 6.3 years. Data before 1983 (*i.e.* before the Sterken group) are probably less homogeneous. A number of other CP stars with suspected long periods are regularly observed within the same project.

The stars HD 98457 and HD 57946 have an extreme photometric amplitude, i.e. about 0.2 mag in the near ultraviolet. This is comparable to the amplitudes previously found for HD 215441, GC 17353 (CpD-55 5216) and for HD 187473. The SiMg star HD 60431 has been monitored in the Geneva system because it shows extreme photometric peculiarity. Surprisingly, its period is as short as 0.476 days, and it is probably the shortest, non-ambiguous period among the Si stars.

Finally, two stars have at least two periods: HD 25267 (τ9 Eri) and HD 37151. They might be intermediate cases between Ap stars and the mid-B variables, one period being due to abundance inhomogeneities and rotation, the other period possibly due to non-radial pulsation.

3. CP2 Stars and Astroseismology

Ten years ago, Don Kurtz announced the discovery of light variations with a period of about 12 minutes for the peculiar CP2 star HD 101065, also known as "Przybylski's Star". Weiss and Kreidl (1980) observed this object at the same time at ESO with Hβ photometry and presented the first evidence that pulsation is the relevant mechanism for its photometric variability.

Observing stars of this class means to detect light amplitudes which are frequently of the order of less than one millimagnitude. Therefore, even for bright stars one needs telescopes of the 1-metre class in order to reduce the photon noise and the scintillation noise due to our terrestrial atmosphere during integration times of only 10 seconds (periods range from about 4 minutes to 15 minutes!). By spectroscopic observations, in particular radial velocity measurements, one can *see* a star pulsating, but obviously still larger telescopes are required to achieve the desired S/N ratio from integration times of one minute at a spectral resolution of R = 100,000.

For stars where one is able to observe several successively excited pulsation modes, one can derive important parameters, like mass and age, internal rotation, depth dependency of a magnetic field, location of a convective zone and the radial dependency of temperature and density. Thus, astroseismology offers a unique way to look into stars and to check the theory of stellar evolution. Further contributions at ESO from our WG: Weiss and Schneider (1984) observed the brightest member of this group, α Cir, with the Walraven photometer attached to the 90-cm Dutch telescope. For the first time, it was possible to investigate amplitudes and phase shifts of pulsation modes in a large spectral range. During a compaign, coordinated by Don Kurtz in South Africa (SAAO), Schneider and Weiss (1986) observed HR 1217 and were able to restrict possible mode identifications. They also took part in a second international observing campaign for HR 1217 in 1986 which resulted in a pulsation frequency spectrum with the highest yet known accuracy (down to the noise limit of 0.1 mmag), besides the sun (submitted). Baade and Weiss computed synthetic spectral line profiles for non-radially pulsating stars, taking different aspect and pulsation parameters into account (1987). Simultaneous spectroscopic and photometric observations of α Cir, obtained by Schneider and Weiss (1989), yielded an upper limit for possible radial velocity variations of 100 m/s in contradiction to 1 km/s claimed by other authors, although the star was pulsating with an amplitude of 6 mmag in Stroemgren *v*. A similar paper on γ Equ is presently being prepared for publication by the same authors. Last year, Schneider and Weiss participated in an international observing campaign, similar to that for HR 1217. The results for HD 203932 are being prepared for publication.

4. Main Sequence Evolution: Search for CP2 Stars in Open Clusters

The study of CP stars in open clusters yields information and constraints on the time dependence of the Ap phenomena. During the discussions in the first two meetings of the WG (Vienna and Paris 1979) it became clear that one has first to identify CP stars in open clusters as completely as possible and to enlarge the sample of open clusters in order to derive statistically sound results. Hitherto published spectroscopic surveys were regarded as insufficient concerning both requirements mentioned.

The way out of the limitations of the time consuming, subjective spectroscopic surveys was provided by the use of photometric indices sampling the Ap typical broad band flux depression around 5200 Å. The first observing runs at the end of 1979 at the ESO 50-cm telescope by Maitzen and Hensberge (1981) used the Δa-index (Maitzen, 1976) to pick out CP2 or CP4 stars in NGC 2516 and NGC 1662. Maitzen and Vogt (1983) demonstrated with a large sample of field Ap stars that Δa has the same detection capability for magnetic Ap stars as the high qualitiy classification dispersion spectroscopy of Bidelman and MacConnell (1973).

Meanwhile 13 papers (for references see Maitzen et al., 1988) have been published on 33 open clusters with slightly more than 1,000 stars surveyed, most of them after 1983. Observations for another 32 clusters have been obtained and are being evaluated.

Our limiting magnitude has been set by telescopes in the range 50 to 100 cm, and is about 11–12 mag, respectively. The number of clusters where a sizable number of objects (i.e. more than 10) can be surveyed in the domain B5–A5 with these limits, is roughly 80. Thus, with our technique and telescopes available we are approaching the end of our programme.

The relatively large number of clusters in our survey is justified by a preliminary evaluation of the results which do not, contrary to Abt (1979), exhibit a simple, clear-cut picture, i.e. dependence with time. Other parameters are probably playing a role in determining how many CP2 stars are present in a cluster and how strong their peculiarities will develop. A careful statistical examination of the data (which are much more homogeneous than spectroscopic results) to be carried out in our WG during this year will try to find out whether there is now enough evidence for statistically sound conclusions. If not, fainter clusters may be included using larger telescopes and CCD techniques. Our actual sample should comprise of the order of 100 peculiar stars, taking into account the frequency of field CP2 stars (about 5 per cent).

The outstanding role of ESO instruments is underlined by the fact that more than half of all observations have been made using either the ESO 1-m, ESO 50-cm or Bochum 61-cm telescopes. This percentage rises to 87, if one considers only the southern hemisphere observations. So far the following participants have contributed to the project: H. Schneider (Göttingen), H.M. Maitzen (Vienna), K. Pavlovski (Zagreb), H. Jenkner (Baltimore-ESA), F.A. Catalano (Catania), H. Hensberge (Brussels), W.W. Weiss (Vienna), T. Kreidl (Flagstaff), G. Deridder (Brussels), M. Floquet (Paris), H.J. Wood (La Serena-CTIO) and C. Tanzer (Vienna).

5. Magnetic Fields

One of the most remarkable characteristics of the Ap stars of the Sr-Cr-Eu, Si, He weak and He rich types is that they possess a magnetic field with a large-scale organization, a unique property among nondegenerate stars. The presence of an organized magnetic field is thus intimately related to the appearance of other peculiarities, in which it most probably plays a key role. Moreover, the magnetic field is likely to have a significant influence on the observed stellar properties, so that its knowledge is an essential part of the proper understanding of the physics of Ap stars. (For instance, the magnetic field must be taken into account when deriving elemental abundances).

Since 1984, a Zeeman analyzer is available as standard option on the CASPEC at the 3.6-m telescope, providing European astronomers with the opportunity of studying magnetic fields of Ap stars from circular polarization measurements in their spectral lines. An observing programme aiming at the determination of the spatially unresolved structure of the magnetic field of a number of stars has been initiated in our WG by Mathys, taking advantage of the unprecedented possibility offered by the Zeeman analyzer of the CASPEC to record simultaneously the *profiles* in circular polarization of a large number of spectral lines, with high S/N ratio. This is a long-term project, since spectra suitably distributed over a stellar rotation cycle are needed in order to untangle the geometry of the field. The acquisition of the data is now mostly completed, for 9 stars a good phase coverage could be achieved; more partial data have been obtained for 25 additional stars. Their analysis is in progress.

Spectra recorded through a Zeeman analyzer essentially contain information about the component of the magnetic field vector along the line of sight. By observing on very high resolution spectra (recorded without a polarimeter) the subtle broadening induced in the spectral lines by the magnetic field, it is possible to study its modulus. This information complements that obtained through spectropolarimetry and thus permits to set more constraints on the stellar magnetic field. The interpretation of the magnetic broadening, however, is not straightforward. A programme is being carried out by Didelon in order to determine whether the Robinson (1980) technique, which has been successfully applied to magnetic field determination in late-type stars, can be employed to measure magnetic fields in Ap stars. The principle of the technique is to compare the profiles of two lines, one which is sensitive to the magnetic field and the other which is not, in order to derive the magnetic field from the difference in their widths. Didelon's observations are being made with the CES at the CAT.

The magnetic field determined with the Robinson technique from unsplit lines is compared with that obtained from lines which are fully split into their Zeeman components by the magnetic field. Not that the latter effect can be observed only in a few stars where the relevant parameters (magnetic field, rotational velocity, angle between the rotation axis and the line of sight) have quite favourable values. One can advantageously use these stars to calibrate the Robinson technique, which can later be applied to determine magnetic fields in less favourable, more widespread cases. A progress report on this project was published recently in the *Messenger* No. 49 (Didelon, 1987).

6. Spectroscopic Studies

The main characteristics defining the various types of CP stars is the anomalous strength of some of their spectral lines. These spectral peculiarities reflect the overabundance or underabundance of some chemical elements in the stellar atmosphere. Abundance determinations are thus an essential part of the study of Ap stars, all the more since they can strongly constrain the theoretical models which are developed to explain the origin of these objects.

Spectroscopic investigations in the region covered by the *International Ultraviolet Explorer* (IUE) have been performed for a number of CP stars. Most of the concerned spectra have their resonance lines in this range. However, line identification is generally hampered by the high density of competing transitions.

Fuhrmann devoted special interest to the well-known CP2 star HR 465, while others like HR 7775, HR 4072, $\varkappa$ Cnc, α2CVn, HD 101065, as well as their "normal" congeners π Cet, ν Cap and Vega were preferably used for comparison purposes. The spectra show a huge number of absorption lines, most of which belong to FeII and CrII. Other elements – like MgII or SiII – have only few, but strong transitions. In the spectra of the CP2 star α2CVn a remarkable number of ions with $Z < 20$ is not well pronounced. This is most obvious in the case of neutral and ionized carbon.

As far as the Rare Earth elements are concerned there are identifications for some second spectra (e.g. HoII, GdII, ...) in the tracings of HD 101065 – Przybylski's star. The spectra of the somewhat hotter HR 465, however, show only marginal contributions from this group of elements. IUE spectra are well suited to show the definite presence of heavy elements like platinum and mercury, as well as the overabundances proposed from optical spectra. Additionally, absorption lines of BiII are observable. There is also strong evidence for transitions due to gold (AuII).

In the *visible,* Gerbaldi and Faraggiana have been extending the investigation of abundances to elements not easily observable with photographic plates. They have derived intriguing results from observations of the neutral lithium resonance line at λ 6707 now easily accessible with modern detectors. The first observations made by them at ESO with CES and Reticon of the LiI 6707 line in cool Ap stars, raised several problems since the feature at this wavelength shows an asymmetric profile different from star to star and an intensity which is not related to the atmospheric parameters of the stars. Surprisingly, the only rough relation detected was that between the equivalent width of λ 6707 and the number of other, mainly unidentified lines present in this spectral range (Gerbaldi, Faraggiana, 1986). Subsequent observations at the Observatoire de Haute-Provence, complementary to those performed at ESO, indicate that a line of another element, so far unidentified, is present at a wavelength very close to the Li line.

Spectroscopic studies of HgMn (CP3) stars were carried out by Schneider (1986), who showed that more than 60 per cent of these stars are binaries. Using new observations he raises this value to more than 70 per cent. This fact puts the CP3 group close to the CP1 (Am) stars, in contrast to the CP2 stars with a binary frequency of only about 30 per cent. The CP3 stars show a concentration towards circular orbits for short periods and a lack of periods less than two days. Stars with periods less than 10 days tend to synchronized rotation. They are all slow rotators with *v·sini* of about 30 km/s.

Abundance analysis of some CP3 stars were carried out by Ansari who carefully studied the effect of rotational broadening of spectral lines on the derived abundance values.

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AK Scorpii: A New Pre-Main-Sequence Spectroscopic Binary

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While we know that perhaps ~25% of normal main-sequence stars are spectroscopic binaries, very few of their progenitor systems have yet been detected among (low-mass) pre-main-sequence stars: Mathieu's (1988) review at the recent IAU General Assembly lists only 11, and for only three had orbits been published at that time. This meagre yield must be due mainly to selection effects mitigating against the discovery of pre-main-sequence binaries. These stars are intrinsically faint and generally found in highly obscured regions, so systematic and accurate radial-velocity observations were impossible until the advent of efficient cross-correlation techniques. Due to their importance for the understanding of star formation processes in general, pre-main-sequence binaries are now being searched for very actively, and the sample will no doubt increase sharply over the next few years. We would like