Peculiar Versus Normal Phenomena in A-Type and Related Stars
ASP Conference Series, Vol. 44, 1993
M.M. Dworetsky, F. Castelli, and R. Faraggiana (eds.)

COMPLICATIONS OF STUDIES OF GALACTIC STRUCTURE, CAUSED BY CP STARS.

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ABSTRACT When studying the distribution of stars and interstellar matter in the galactic environment, one relies upon objects which are numerous enough and also bright enough to constitute workable samples. A-type stars seem to be a natural choice, but a successful study then depends on the reliability of the spectroscopic distance determinations. Since chemical peculiarity affects a considerable fraction of the A-type main sequence stars we have found reason to investigate the reliability of luminosity estimates for stars of various types of peculiarity. The result indicates that peculiarity is a less serious problem than undetected multiplicity.

INTRODUCTION

At traditional studies of stellar distribution in the relative neighbourhood of the sun, the basic procedure is an estimation of spectroscopic distance to clusters and associations of various type and degree of stellar density. For such projects the target stars should be both frequent and bright. Unfortunately there is a very pronounced counter-correlation between brightness and frequency, and hence one has in practice to rely upon some compromise. It turns out to be the A-type stars and, in fact, the study of galactic fine structure is a typical A-star project.

However, there are a series of problems interfering at studies of A-type stars, particularly:

1. High frequency of multiplicity with components which are sometimes so equal in temperature that, if not revealed by Doppler effect, they appear as one single star showing a completely deceptive absolute magnitude.

https://doi.org/10.1017/S0252921100021102 Published online by Cambridge University Press

2. Rapid rotation causing broad blurred lines and hence classification difficulties.

3. High luminosity without reasonably good absolute magnitude calibration.

4. Evolutionary effects.

5. Chemical peculiarity.

If all stars in a cluster or association with at least one of these complications revealed should be withdrawn from the program, there should be too few stars left for statistical treatment. Therefore it is near at hand to investigate if, for instance, some CP stars could be included in a selection without introducing intolerable errors in the result.

TYPE OF PECULIARITY AND GALACTIC POSITION

A premature idea was that the chemical peculiarity itself might constitute a tool at studies of certain galactic elements (Lodén 1984). If the surface composition of all members of a cluster had some characteristic property in common, one should have a useful method for discrimination of member stars from nonmembers. No such CP property was found, at least none of practical importance. This circumstance is also palpably confirmed by the fact that there is a pronounced discordance between peculiarity classifications performed by different observers (table 1).

DEGREE OF PECULIARITY

Instead of peculiarity classification according to type it is also possible to perform a corresponding classification with respect to degree of peculiarity. The result indicates that, however you define the CP criteria, you will find a continuous transition from extremely normal to extremely peculiar stars (Lodén and Sundman 1987). Roughly one could say that, in fact, there are no really "normal" A stars, particularly if you take the rotational velocity and attitude in consideration (Abt and Moyd 1973).

This means that a considerable fraction of the stars used at definition and calibration of color, temperature and luminosity, is composed by more or less "peculiar" stars whether or not the peculiarity was revealed at the calibration occasion.

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Primary class.	Hg HgMn	Mn	Si	Si 4200	SiSr	SiCr	Sr	CrSr	CrEu	CrSr Eu	Am	delta Del	Other CP	Nor- mal
Ap	7	2	22	7	3		12	2		7	32		6	
Am			1		1		2		1	1	69	3	2	20
Hg,HgMn	22	30	11	11	2					2			2	20
Mn	64	8	14											14
Si	3	2	27	24	2	8	2	2	2	2	2		6	18
Si 4200	8	4	68	9		4			1				1	5
SiSr	3		9			9	3		3	41	17		9	
SiCr			40	9	9				16	2			21	
Sr			10		2		12	23	2	21	18		6	6
CrSr			9				25	9	9	32			9	7
CrEu			8	3	3	15	3	8	5	15	14		21	5
CrSrEu	1		6		3	19	14	19	8	11	4		15	
del Del											52	12		36
Normal	6	2	22	2	1	1	2	2	1		54	6	1	---

Table 1. The relative distribution of classifications according to Bertaud and Floquet (1974). For each star with more than one source of CP classification the frequency of the various alternatives are shown. It goes without saying that the absolute number of classifications will exceed the number of stars classified. Note that a considerable number of stars have been classified as Am by some observers and as Ap by others.

PECULIARITY AND LUMINOSITY

According to consensus, "traditional" CP stars are main sequence objects (Baschek and Oke 1965, Böhm-Vitense 1960, Conti 1965, Smith 1971, van't Veer-Menneret 1963). However, in the Michigan Catalogue (Houk et al 1975-88) one finds stars classified as both chemically peculiar and above-main-sequence luminous. Surprisingly then, a comparison with a sample selection of "normal giants", "normal main sequence stars" and "peculiar main sequence stars" did not show any significant indication of combination of peculiarity and high luminosity (Lodén and Sundman 1989).

One might conclude that although some CP spectra show characteristics of high luminosity, these characteristics should not be interpreted as crucial ones. In general CP stars should still be regarded as dependable main sequence objects.

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CALCIUM LINE MISCLASSIFICATION

If the intensity of a certain line is influenced by abundance particularities, it may cause either luminosity misclassification or temperature misclassification, occasionally both. For illustration we mention here the conspicuous calcium lines Ca I 4226 and Ca II 3933 (K-line). They are both in a complicated manner sensitive to chemical peculiarity and behave, at least apparently, rather capriciously. Their general tendency with respect to various type of peculiarity is schematically illustrated in figure 1.

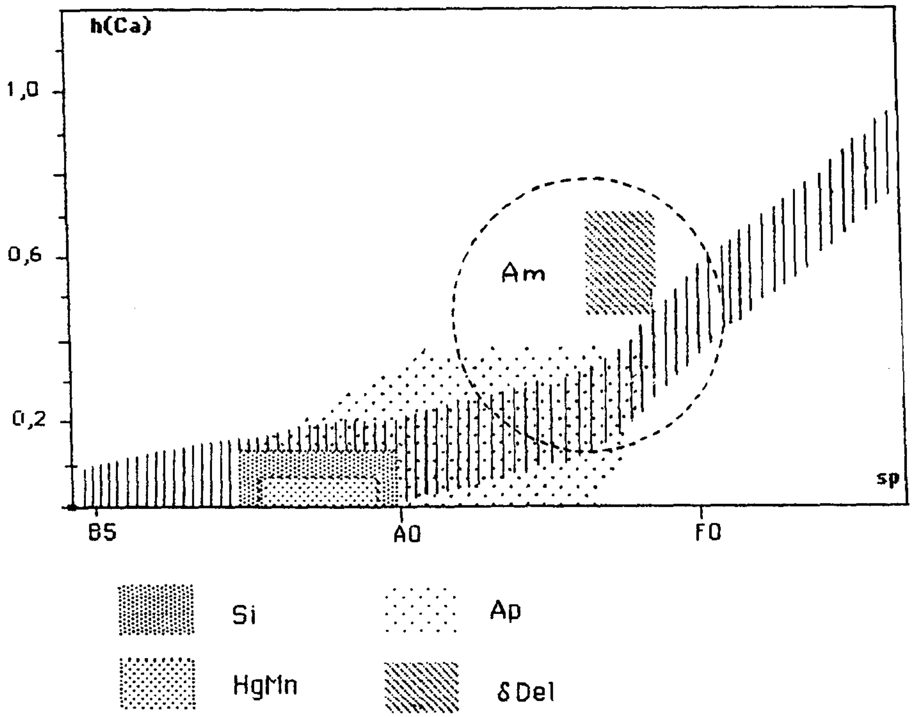

Fig 1. The correlation between Ca-line intensity and spectral type when classified entirely from UBV color and Balmer line intensity. The Ca-line intensity is calculated from a combination of K-line equivalent width and Ca I 4227 line depth on an arbitrary scale, normalized to maximum value 1. The vertically dashed area represents "normal" stars. The encircled region is the domain of the Am stars. "Ap" essentially covers the types Sr, Cr and Eu or combinations of these elements.

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THE ROLE OF THE ROTATION

The B-type stars show stronger Balmer lines with increased rotational velocity, while the Balmer lines tend to become weaker in rapidly rotating A-stars. Inclination effects may also produce appreciable differences in the Balmer line profiles (Slettebak and Kuzma 1979). Since statistically the rotational velocity is lower for CP star than for more "normal" ones, one might consider this group of stars as slightly more dependable.

TYPE OF PECULIARITY AND DEPENDABILITY

Ap Si constitute a majority of all stars classified as Ap and appear to be normal with respect to luminosity and color. However, the classification characteristic lines of Si II are highly luminosity sensitive, and chemical peculiarity could easily be misinterpreted as gianthood.

Ap Hg(Mn) are probably reliable main sequence objects (Lodén and Sundman 1991). The fact that a large fraction, possibly a majority, escape detection, might indicate that no really "normal" stars at all appear within the actual temperature interval.

Ap CrSrEu is also found to be normal with respect to luminosity and color, and there are no significant differences between stars classified as CrSrEu, CrEu, CrSr etc. Some precaution must be taken: Peculiarity characteristics coincide with luminosity characteristics, and there is a pronounced tendency for CP stars in this range to show multiplicity.

Am stars are most probably main sequence objects, albeit they seem to be slightly displaced along the ZAMS in relation to "normal" stars, classified with respect to the Balmer lines (Baschek and Oke 1965). An additional circumstance is the poor distinction also between Ap and Am stars (Smith 1974, Wolff and Wolff 1974). See also table 1. Since the risk for multiplicity is very high for the Am stars (Abt 1961, 1965), discordant classifications can be explained as a result of combination of spectra of multiples with nearly equal components. Serious attempts to calibrate the absolute magnitude of Am stars have given an average value corresponding to about one magnitude unit brighter than the presumptive main sequence value. (Gomez et al 1981). Compared to main sequence stars in our material the excess is slightly less than 0.4. Since higher multiples than binaries are rather common, certain intensity excess for the Am stars could well be explained in terms of additional, unrevealed multiplicity. Besides, the definition of spectral type is not unique when Am stars are concerned and this also affects the absolute magnitude calibration.

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δ Delphini stars are generally regarded as a subgroup of the Am stars and representing an evolved state (Kurtz 1976, 1978). This implies a higher luminosity than the corresponding main sequence objects and these stars may introduce a systematic distance error if admixtured in a sample selection. It seems, however, as if these stars should appear only within a rather narrow temperature region close to 7500 K, and by avoiding of this region the risk should be eliminated (Lodén 1991).

CONCLUSION

Chemical peculiarity of upper main-sequence stars cannot be used in practice for any kind of discrimination. On the other hand it is fairly harmless at statistical studies of galactic structure - provided that one omits stars coolwards of A8.

The overwhelming menace to accurate distance determination to faint A stars is connected with treacherous components.

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