Peculiar Versus Normal Phenomena in A-Type and Related Stars
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MK PROCESS AND THE Am STARS

SREEDHAR RAO, S. and ABHYANKAR, K. D.
Centre of Advanced Study in Astronomy
Osmania University
Hyderabad 500 007 - India.

ABSTRACT The MK morphology of the spectra in the region λλ 3850-4400 Å of 28 Am stars has brought to light the tendency of these stars to form into groups in contrast to earlier findings by various authors (S. Sreedhar Rao & K. D. Abhyankar, 1991). The potential of such a study is seen in the revelation of the inherent flexibility of the stars in this sample, apparently leading to a selective binning of the species with distinctly similar signatures, viz., Ca II K and Sr II 4077 features, the blue and violet regions and the Am-shell features. These are found to be the essential discriminants on the basis of which a multi-dimensional classification of Am spectra in the domain of the MK process is attempted.

INTRODUCTION

Of the 1700 A-type stars classified by Cowley et al (1969), 1400 could be assigned spectral types on the MK system while the rest did not fit the scheme. Among them 11% are Am, 10% are Ap stars while the remainder constitute 1.6%. Thus the MK system identifies itself with a vast majority of normal stars which obviously depend upon the definition of normalcy. The MK system *per se*, being narrowly defined, may be powerless, in a situation like the one it faces in the case of the eccentric Am spectra. It therefore requires to be augmented by more frames of reference with specific characteristics in a specific wavelength interval and each specimen occupying a single classification box. Morgan (1984) described this method that permits the development of such a classification system by which it is possible to classify population II stars as well as the peculiar spectra. This procedure has been labeled as the MK process.

A global or morphological evaluation of Am stars is necessary for a meaningful and unambiguous classification by means of the MK process. The spectral morphology is the description of the continuum and line spectrum of a star which facilitates a self classification by showing where the degree of change is most discernible between various regions of its spectrum. The use of patterns instead of line ratios in the classification of the stellar spectrograms and scans increases the classification resolution and it's accuracy.

Thus MK spectral morphology of the Am stars provide the exact scenario for the application of such a process for their spectral classification.

OBSERVATIONS

Well widened spectra of a random sample of 28 Am stars and those of 39 MK standards, in the classical MK domain, were obtained at a linear reciprocal dispersion of 66 Å mm^{-1} with the Meinel spectrograph at the Nasmyth focus of the 1.2m telescope of the Japal-Rangapur Observatory, Osmania University. All the observations were made during the same observing season of 1987-88, with the same system, using Kodak IIa-O plates which were processed in identical manner. The spectra were digitized for use in the morphological study.

SPECTRAL CLASSIFICATION

The MK morphology of the stars in our sample (Sreedhar Rao and Abhyankar, 1991) confirms the pseudo-luminosity effect observed by Abt and Morgan (1976) and it has revealed the following spectral characteristics which discriminates them from the normal standards of the MK System.

(a) The weak Ca II K feature corresponds to a dwarf in all the stars of our sample.

(b) The blue region($\lambda\lambda$ 4260-4400 Å) corresponds to an F type subgiant or a dwarf. Besides the lines comprising the G-band region, the λ 4315 Å feature and $\lambda\lambda$ 4383-86 Å blend are also luminosity sensitive, indicating a brighter luminosity class.

(c) The violet region ($\lambda\lambda$ 3850-4100 Å) corresponds to an F giant or even a supergiant.

(d) The Sr II 4077 feature in the violet region, however, exhibits a higher luminosity class than the rest of the spectrum in two-thirds of the sample. This difference apparently determines whether the spectrum is variable. In HD 93903, a single line binary, it's strength varies with phase (Sreedhar Rao, Abhyankar and Nagar, 1990).

(e) The weak-lined Am stars do not exhibit the differential luminosity effects and their spectra almost conform to the boxes in the MK System. They comprise about 20% of our sample and some of these could have been wrongly classified.

(f) Am-shell features are exhibited by some of the stars in our sample in different spectral regions; the strength and sharpness of the metallic lines being similar to that in the extreme A-shell spectrum and MK standard HD 41511, illustrated by Abt, Morgan and Tapscot (1978). Especially, the entire metallic line spectrum of HD 76756 resembles that of HD 41511 (JD 244 7131.38) except for Sr II 4077 Å feature.

It is apparent that the stars in our sample arrange themselves into different baskets; each having several outstanding discriminants. We define the classification boxes specifying:

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(i) The K type, (ii) and (iii) the luminosity classes of the metallic line spectrum in the violet (v) and blue (b) regions and (iv) the comparison with the luminosity class given by the Sr II 4077 feature where, - and + signs represent a lower or higher class. Further, we have added letter s to the K line type when the spectrum resembles that of an A-shell. The typical members of various boxes are given against each box.

Box 1 : (K A2, 3V, v AV, b AV, Sr ≈ v-)	HD 41841
Box 2 : (K A3V, v FI, b FIII/IV, Sr ≈ v)	HD 32667
Box 3 : (K A7Vs, v FIII, b FIII/IV, Sr ≈ v)	HD 76756
Box 4 : (K A7IV, v FIII/IV, b FIII/IV, Sr ≈ v+)	HD 15385
Box 5 : (K A4V, v FI, b FIII/IV, Sr ≈ Ap)	HD 27749
Box 6 : (K var, v var., b var., Sr var.)	HD 93903

It may be noted that these boxes arrange the stars with increasing intensity of Sr II line. Further, our Box 1 is nothing but the old weak or marginal Am class, while Box 6 classifies the transition class between Am and Ap stars represented by stars exhibiting phase modulated spectral line variation, as pointed out by us earlier (Sreedhar Rao, Abhyankar and Nagar, 1990). The spectral scans in the classification regions of the stars are shown in the Appendix.

CONCLUSIONS

In view of our results it seems necessary to find more members in each of the above boxes of Am stars so that the system becomes more well defined. Such a survey might also reveal additional discriminants for each classification box.

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Appendix

In figures 1 to 6 (relative intensity vs. wavelength in A) the top panel shows the K line spectrum, the middle panel shows the 'v' spectrum and the bottom panel shows the 'b' spectrum.

The strontium line is marked in the middle panel. In each case the thick line represents spectrum of the star and the thin line that of the MK standard.

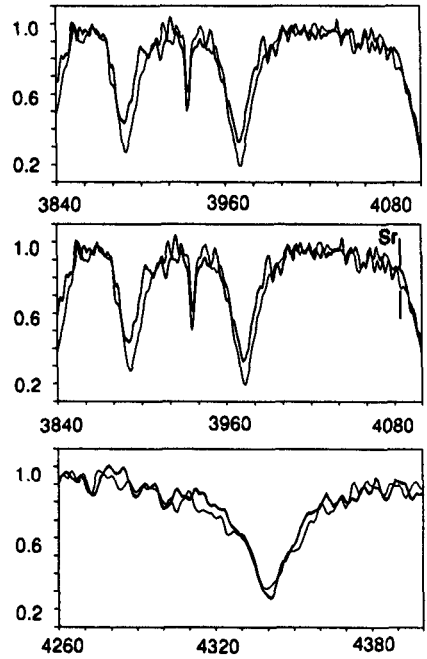

Fig.1 : Box 1 - HD 41841

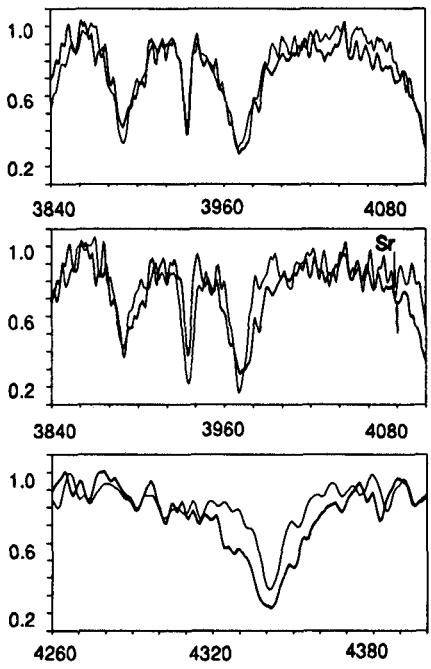

Fig.2 : Box 2 - HD 32667

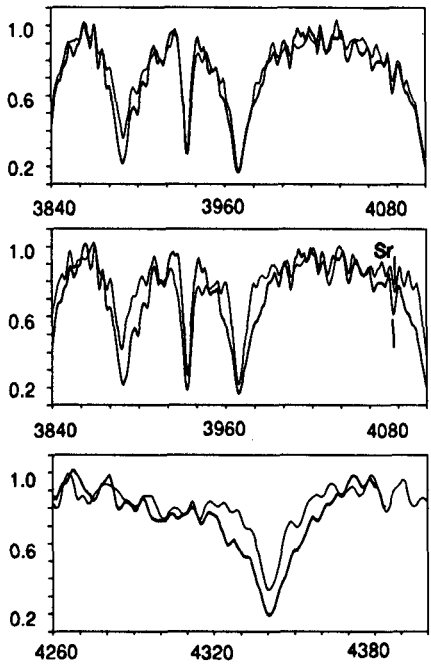

Fig.3 : Box 3 - HD 76756

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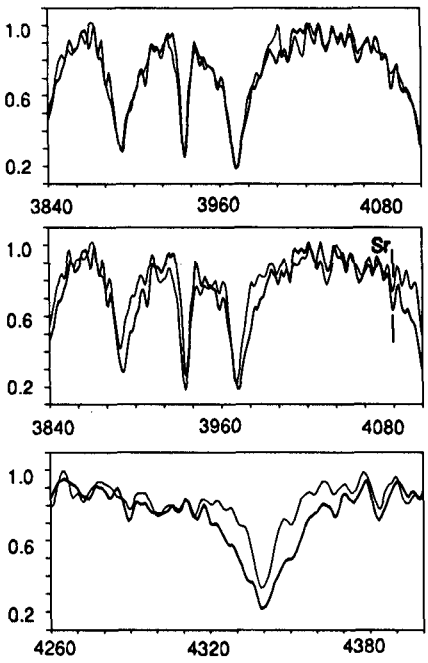

Fig.4 : Box 4 - HD 15385

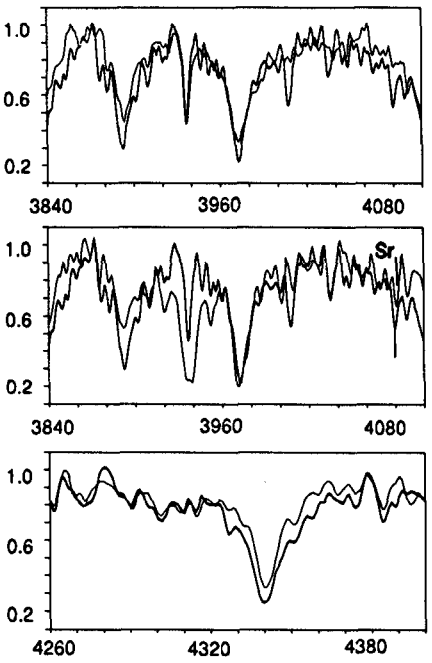

Fig.5 : Box 5 - HD 27749

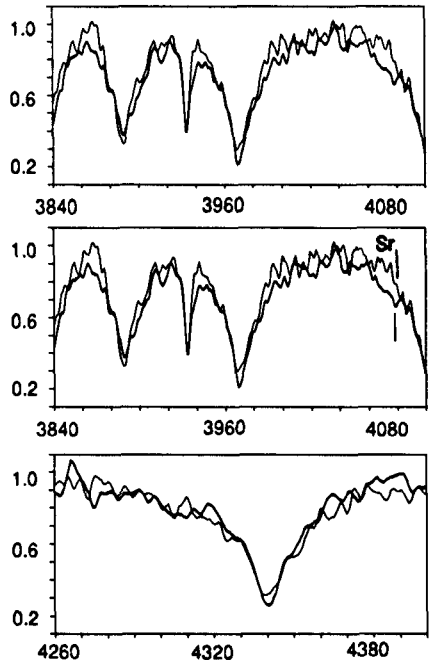

Fig.6a : Box 6 - HD 93903 $\phi = 0.37$

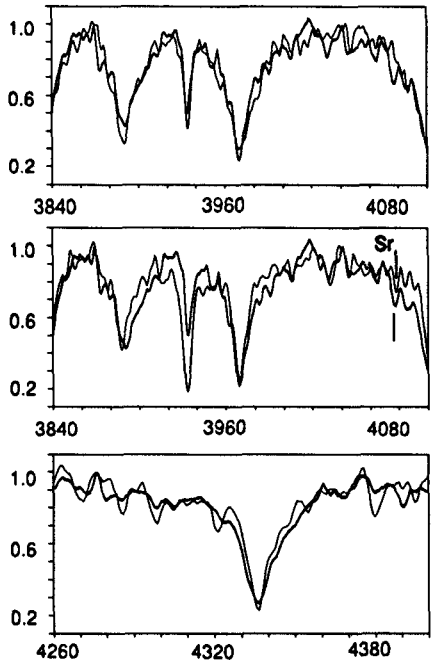

Fig.6b : Box 6 - HD 93903 $\phi = 0.54$

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DISCUSSION (Sreedhar Rao and Abyankhar)

COWLEY: A comment on the Am phonomenon: we put a lot of effort and importance on calcium. Now calcium just happens to be an element whose lines can be seen at classification dispersion. From the point of view of the chemical history of these stars it is not clear to me that calcium is more important than scandium or oxygen or barium, whose lines are not seen at low dispersion. When we look at high dispersion, we find many of these elemental abundances varying within the Am's. So I am not at all surprised that you find several sub-classes.
CORBALLY: I appreciate your application of the MK process rather than the specific MK system to this problem of the Am stars. Since indeed Sr II is not a good luminosity indicator in the Am-Fm temperature region (but rather, e.g., 4172-78 Å), would you clarify how you derived your luminosity classes for the two regions, violet and blue?
SREEDHAR RAO: We have compared the corresponding regions in both the standard stars and the Am stars to determine the spectral class, rather than using specific luminosity discriminants which are used to define the MK boxes. Sr II is highly sensitive to luminosity and its comparison with the luminosity class of the violet region (3850 Å - 4078 Å) appears to be a characteristic discriminant in Am stars.

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