A NEW LOOK AT THE Am STARS

C. Burkhart
Observatoire de Lyon
69230 St Genis-Laval
France

M.F. Coupry and C. van't Veer
Institut d'Astrophysique de Paris
98 bis Bd Arago
75014 Paris
France

ABSTRACT. High resolution, high signal-to-noise observations are required for a better understanding of the Am stars and related topics. Two examples are shown : the relationship between lithium content and temperature in the Am stars of the Hyades cluster and the observational problem induced by multiple spectroscopic binarity frequent among the Am stars.

1. INTRODUCTION

Up to now, there are very few studies of Am stars performed with the new spectroscopy, that is high resolution, high signal-to-noise. Yet, the new spectroscopy allows:

- the study of the abundances of new elements such as He,Li,C,N, O, which appears very interesting especially as the best theory to explain metallic-line stars properties, the diffusion theory, leads to the best accurate computations in the case of the light elements,
- better abundance estimates thanks to better spectra making weak lines available, which is important because the atmospheric abundance anomalies of the Am stars are mild and a higher accuracy is necessary to hope for the construction of any diffusion model of a given star, to show up from star to star any correlation between elemental abundances, or any pattern of an atomic sequence (Sr,Y,Zr; the Rare Earths;...), and
- the discovery and the study of the multiple spectroscopic binarity whose occurence is very high among the Am stars.

Here, we exhibit some results on the lithium abundance in the Am stars of the Hyades cluster and how the binarity is an observational problem for these stars.

All the spectra were obtained in the region λλ6675-6725 with the coudé spectrograph of the Canadian-Franco-Hawaïan 3.6m telescope, the 1800 lines/mm holographic grating, and a cooled Reticon array of 1872 diodes. The dispersion is 1.97 Å/mm or 0.0295 Å/pixel. The signal-to-noise is generally greater than 300.

G. Cayrel de Strobel and M. Spite (eds.), The Impact of Very High S/N Spectroscopy on Stellar Physics, 401–406.

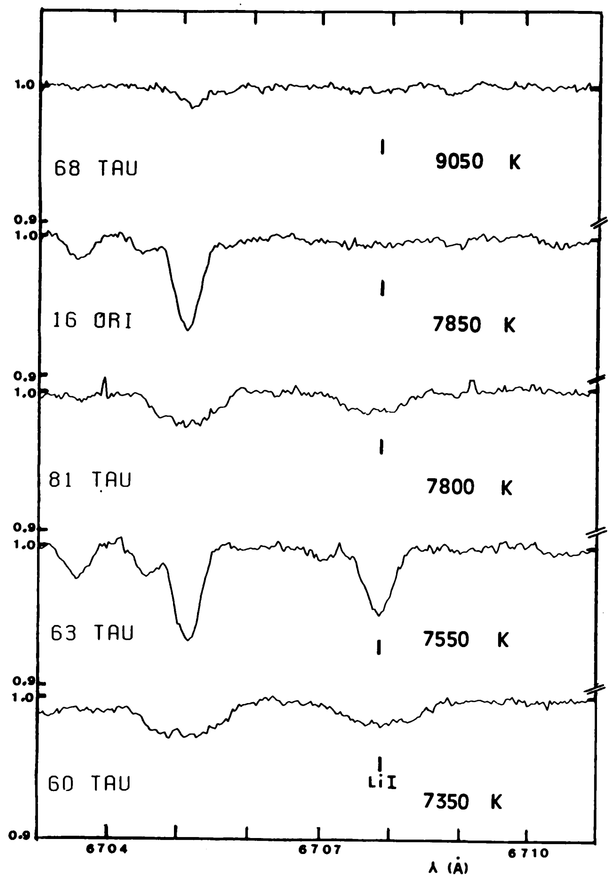
1.0
68 TAU
9050 K
0.9
1.0
16 ORI
7850 K
0.9
1.0
81 TAU
7800 K
0.9
1.0
63 TAU
7550 K
0.9
1.0
60 TAU
Li I
7350 K
0.9
6704
6707
6710
λ (Å)

Fig.1

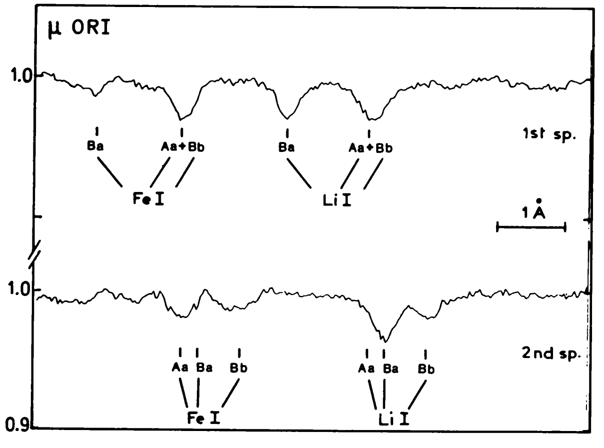
μ ORI
1.0
Ba
Aa+Bb
Ba
Aa+Bb
1st sp.
Fe I
Li I
1 Å
1.0
Aa Ba Bb
Aa Ba Bb
2nd sp.
Fe I
Li I
0.9

Fig. 2

2. LITHIUM IN THE Am STARS OF THE HYADES CLUSTER

Figs. 1 and 2 show a part of the spectral region observed for 6 Am stars of the Hyades cluster. Fig.3 shows the Li abundance results as a function of the temperature. The temperature T_{eff}, which is of critical importance in the abundance determination, is determined from uvby,β photometry. A set of model atmospheres (Kurucz,1979) is used to calculate the equivalent width of LiI-6707Å as a function of T_{eff} in the weak-line limit. The Li abundance follows from the measured λ6707 Å equivalent width.

For the 6 Am stars, ranging from 7500 to 9000K, presumably having all the same age and the same original interstellar material, the Li abundance is constant - logN(Li)=3.0 with logN(H)=12, hereafter called the normal Li abundance -, excluded one star deficient by 0.7 dex, its temperature =7850K.

If we compare these results with those of A.Boesgaard (1987) for 5 Am stars of the Coma Berenices cluster of nearly the same age as the Hyades cluster, the same outline appears : the Li abundance is normal except near 8000K where the abundance range is 0.75 dex.

We have no total explanation of these results. A large range of the Li abundance is expected by microscopic diffusion processes, the actual abundance in the surface being very sensitive to the depth of the mixing zone. On the other hand, the stars with abnormal Li abundance are not very far from the turn-off of the clusters. We may wonder if changes in the structure of the stellar envelope induced by some weak evolution have no crucial effects for the processes acting upon the elements.

Other parameters than temperature and depth of the convective zone, age and degree of evolution, such as rotational velocity, mass loss... must be considered. More observations with the new spectroscopy are needed to disentangle the different parameters, but it must be certainly rewardful as well concerning the understanding of the Am stars and information about their stellar envelope as a better insight of the hydrodynamical processes involved where 2 adjustable parameters, the mixing length and the microturbulence are employed.

3. MULTIPLE SPECTROSCOPIC BINARITY

Multiple spectroscopic binarity may induce mistakes when assuming a line to some component.

Thus, the careful investigation of the close triple system μ Ori of the Hyades cluster by Fekel(1980), using Mc Donald 2.7m, the coudé spectrograph and a Reticon array, allowed us a correct connection between the lines observed and the 3 components in Fig.2 and avoided us to find μ Ori Aa to be an Li- overabundant Am star by a factor of 4, taking advantage of the accuracy of the wavelength and the line profile of our spectra.

Multiple spectroscopic binarity stops any study of abundance determination if the system is not well-known and this frequently occurs among

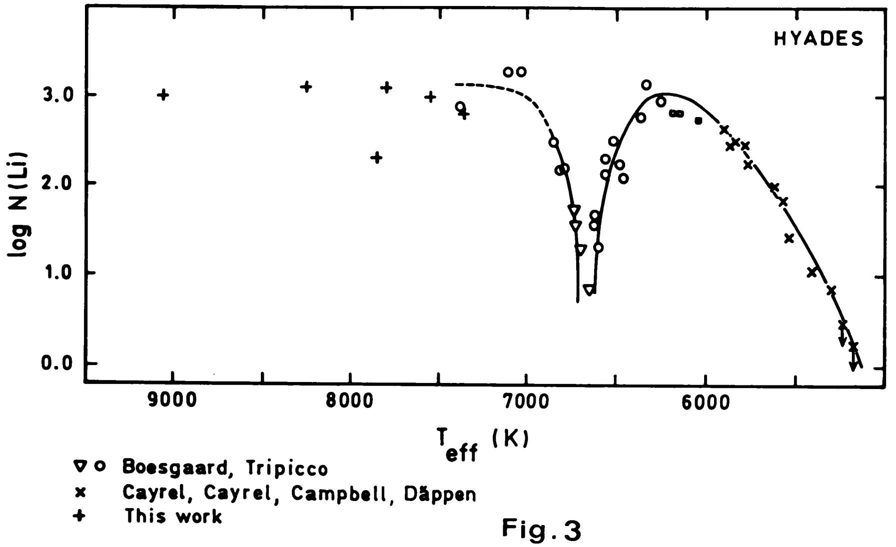

Fig. 3

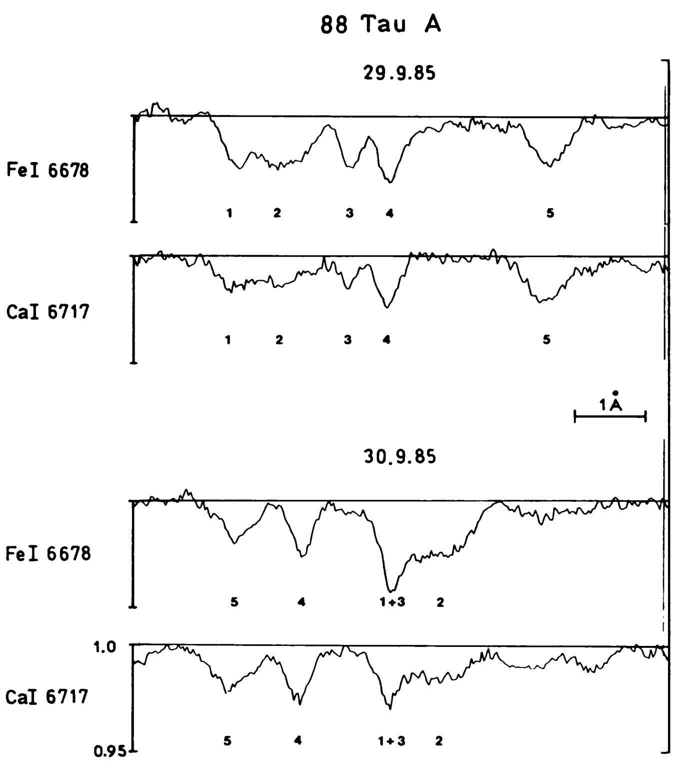

Fig. 4

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the Am stars.

Thus, 88 Tau A (V=4.25) was known to be a SB2 Am star and lately resolved by speckle. In the lithium wavelength region, Fig.4, 5 systems of lines clearly appear. From the first observation to the second one, we were able to recognize each component but any abundance determination has to wait for a comprehensive study of this peculiar system.

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DISCUSSION

GERBALDI A remark : The λ 6708 region has been observed with high resolution at ESO in order to detect and analyse the abundance of Li in a sample of cool CP2 stars. Very puzzling results were obtained : see in particular : Faraggiana, Gerbaldi, Castelli, Floquet, 1986, Astron. Astrophys, 158 200. More observations made at Observatoire de Haute-Provence (Gerbaldi, Faraggiana, 1987, Colloquium "l'Histoire et l'Avenir de l'OHP") reveal a far more complicated situation. Three stars having the same T_{eff}, the same log g ,the same spectroscopic peculiarities (Sr, Cr, Eu lines enhanced) have a blend at 6707.8 Å -the position of the LiI doublet- strongly different from one star to another, and close to it we notice unknown features.
Moreover 70% of our sample of observed cool CP2 stars do not present any feature at all at the wavelength of Li.
So we ask the question : can this feature at 6707.8 Å be attributed only to the Li or is it due to the Li and something else or even no Li at all?

MEGESSIER My question concerns the effective temperatures. In the case of Ap stars, it is known that, due to the UV flux deficiency, the T_{eff} determined from the visible flux are overestimated. What is the situation for the Am stars?

BURKHART Contrary to the Ap stars, the Am stars are only slightly abnormal and the difficulties for the T_{eff} determination exist, but are not so big.

BOESGAARD It is interesting that the Hyades seem to have another Li "quirk" at ≃8000K.
Was your temperature scale (calibrated by Moon and Dworetsky from Hβ) 100K hotter or cooler than the Boesgaard-Tripicco scale for the F stars? What is the full range of v sin i values for the Hyades Am stars and what was the v sin i range for those stars that you observed for Li?

BURKHART We have only one Hyades star in common with Boesgaard and Tripicco : our temperature is 50K cooler. The Boesgaard temperature scale (calibrated by Böh-Vitense from (B-V) for the 5 Coma Am stars is not different from the Moon scale.
The highest v sin i is 80km/s for the Hyades Am stars and we observe only up to 25km/s, i.e. a third of the full range.