CHEMICAL COMPOSITION OF THE FOUR HYADES GIANTS

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ABSTRACT. Differential detailed analyses with respect to ϵ Vir of the four Hyades giants have been carried out on high resolution high S/N CFHT Reticon spectra. The preliminary results are given below.

1. INTRODUCTION

Differential detailed analyses of 12 dwarfs of the Hyades cluster have been carried out by Cayrel et al. (1985). This paper deals with a similar analysis, but for the 4 giants of the cluster. Its aim is to compare the metal abundance found in two samples of stars of the same cluster being in a different stage of evolution.

2. OBSERVATION, REDUCTION AND METHOD OF ANALYSIS

High resolution, high S/N spectra in three spectral intervals at λ5890, 6560, and 6750A have been obtained for the Hyades giants γ Tau, δ Tau, ϵ Tau, and θ^1 Tau, using the coudé spectrograph of the Canada-France-Hawaii Telescope (CFHT). The average S/N ratio obtained for these spectra was about 300:1 and their resolution ≃ 0.2Å. Equivalent widths of metal lines have been obtained with a profile fitting technique that accounts for blends. Special care has been given in determining the continuum, always a delicate question in these late type stars.
The spectra have been interpreted with theoretical line computations using the grid of model atmospheres computed by Bell and Gustafsson (1978). The G9III star ϵ Vir has been used as comparison star. The spectra of ϵ Vir have been obtained with the same instrumentation and the same S/N ratio.

3. RESULTS

The effective temperatures of the 4 giants have been derived from the photometric (T_{eff}, V-K) calibration for giants by Ridgway et al. (1980). The spectroscopic gravity has been obtained from the ionization

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equilibrium and the microturbulent velocity from the curves of growth. No significant difference in gravity and microturbulence has been found between the 4 giants. We have found log g = 2.7 and ξ_t = 1.7 km.s-1 for the 4 stars. Their iron abundance is also very similar, the mean value is :

$$[Fe/H]^{\text{Hyades giants}}_{\epsilon\ \text{Vir}} = +\ 0.11 \pm 0.03.$$

However, in analysing ε Vir with respect to the sun, we have found slightly, but significantly, enhanced iron abundance , i.e. :

$$[Fe/H]^{\epsilon\ \text{Vir}}_{\odot} = +\ 0.09 \pm 0.03.$$

In taking T_{eff}(ε Vir) = 4990, log g = 2.7 and ξ_t = 1.7 km.s-1, the iron abundance of the giants with respect to the sun is then :

$$[Fe/H]^{\text{Hyades giants}}_{\odot} = +\ 0.20 \pm 0.03.$$

All the other elements analyzed in the 4 giants have abundances varying in lockstep with iron, except sodium. The mean abundance value for sodium is :

$$[Na/H]^{\text{Hyades giants}}_{\odot} = +0.5 \pm 0.1.$$

4. DISCUSSION

Table 1 gives chromospheric and coronal emissions, X-ray luminosity, effective temperature and Fe and Na abundances for the 4-Hyades giants. Ca II K and Mg II (h+k) are taken from Baliunas et al. (1983), logL_X from Stern et al. (1981), T_{eff}, [Fe/H], and [Na/H] come from the present study.

Table 1 Chromospheric and coronal spectra CaII K, MgII(h+k), X-ray luminosity, effective temperature, abundance.

Star	Ca II K	MgII(h+k) (10^3ergs/cm²/s)	LogL_X (ergs/s)	T_{eff} (K)	$[Fe/H]_\odot$	$[Na/H]_\odot$
θ^1 Tau	0.60	587	30.0	5050	0.19±0.02	0.5
γ Tau	0.48	566	29.4	4990	0.20±0.02	0.5
δ Tau	0.26	345	28.9	5000	0.21±0.02	0.5
ε Tau	0.18	334	–	4950	0.23 :	–

From columns 2 and 3 of Table 1 we see that θ^1 Tau and γ Tau have a more active chromosphere than δ Tau and ε Tau. No significant effect of chromospheric activity on the derived abundances is visible, in contrast to what was found by Cayrel et al. (1985) in a sample of 12 dwarfs of the Hyades. Surprisingly, the iron abundance found in the giants is slightly larger (+0.08 dex) than the one found in the dwarfs, Cayrel et al.

(1985). As no iron enrichment is possible from core nuclear burning and mixing, this difference can be only attributed to spurious non LTE or chromospheric activity effects.

Finally the evolutionary stage of the 4-Hyades giants is discussed. Figure 1 shows the (B-V,V) diagram of the Hyades from Johnson et al. (1962). Superimposed are evolutionary tracks by Iben (1965, 1967) for stars of 2.25 and 3.0 $M_\odot$; Y=0.29, Z=0.02. Two major nuclear burning phases, the hydrogen-core and the helium-core burnings, are indicated by thick lines. Fig. 1 demonstrates that the positions of the 4-Hyades giants in the (B-V,V) diagram correspond to the core-helium burning phase of stars with $2.5<m/M_\odot<3.0$. Thus, the estimated mass is well beyond the critical mass $m\simeq2.25M_\odot$ for the electron degeneracy in the core during the first ascent of the red giant branch.

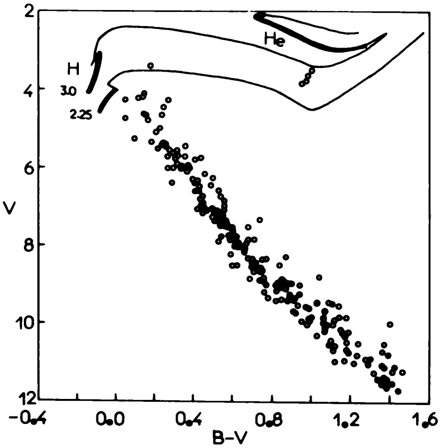

fig.1

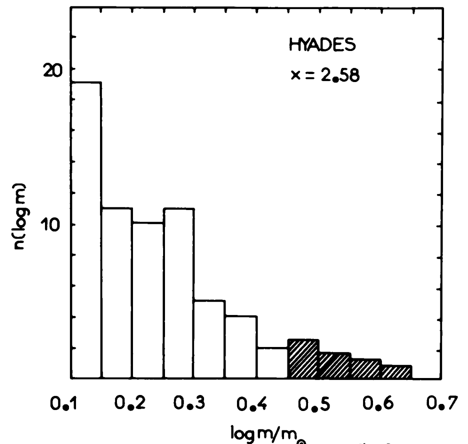

fig. 2

Fig.1. The (B-V,V) diagram of the Hyades. Superimposed are evolutionary tracks by Iben (1965,1967) for stars of 2.25 and 3.0 $M_\odot$; Y=0.29, Z=0.02.

Fig.2. The mass distribution of the Hyades dwarfs (non-hatched) from Tarrab (1982) and the predicted mass distribution for the giants (hatched).

It is well known that only 4 yellow giants have been found in the open cluster of the Hyades. It was therefore interesting to estimate the expected number of giants in the cluster by using its initial mass function (IMF). Tarrab (1982) found that the observed mass function of the Hyades is well approximated by a power-law of mass, $\phi(m) \propto m^{-\mu}$, with μ=2.58 [for the Salpter's (1955) IMF, μ=1.35]. Figure 2 shows the mass distribution of the Hyades dwarfs (non-hatched bins) in the mass range of $1.3 \leq m/M_{\odot} \leq 2.8$ (Tarrab,1982) and the predicted mass distribution for the Hyades giants (hatched bins) of $2.8 < m/M_{\odot} \leq 4.5$ by using the same slope of μ=2.58. From Fig.2, we find that the expected number of giants in the mass range of $m/M_{\odot} \leq 3.0$ is about 2. The difference between the predicted and the observed number of the Hyades giants is consistent with the Hyades IMF so far as all the 4-giants are in the core-helium burning phase.

5. CONCLUSION

The iron abundance is very similar in the 4-Hyades giants, its mean value is [Fe/H]=+0.20±0.03. This significantly higher metal abundance of the Hyades giants with respect to the dwarfs and the constancy of their values in all the giants could be a non LTE effect or a consequence of a different effect from chromospheric activity between giants and dwarfs. With the help of the IMF (μ=2.58) and stellar evolutionary models, it seems that all the 4-giants are in the core-helium burning phase.

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DISCUSSION

GRIFFIN How did you estimate the surface gravity?

ARIMOTO With the help of the ionization equilibrium.

GRATTON Two questions and a comment. 1)What is the mass you infer from the gravity you use? 2) What is the influence of an atmospheric structure which might be different from dwarfs and giants on your abundances? 3) It would be interesting to have more than the Na D lines to derive Na abundances. Chris Sneden and me found an analogous result for Na abundances derived from D lines in metal rich stars.

CAYREL DE STROBEL 1) In the paper by Cayrel et al. (1970) using the same log g=2.7 we have found 2 $M_{\odot}$ for the giants. 2) Dr. Gustafsson will comment on this question, in this invited paper, (see in particular the best part of the discussion after Gustafsson's paper). 3) In the three Reticon spectral intervals we have studied no weak sodium lines are present, so we have had at our disposal only the strong D lines.