The atmospheric model parameters of Eta Leo

ABSTRACT

We redetermined the atmospheric model parameters of η Leo (A0Ib) on the basis of a set of equivalent width data of 47 FeI and 71 FeII lines, measured previously by B. Wolf (1971). The procedure followed is an iterative one, involving the determination of the depth variation of microturbulence. We find $T_{\rm eff}$ = 10200 K $\pm$ 370; log g = 1.9 [cm s^{-2}]$\pm$ 0.4 and $\Delta\log Z$ (=logarithmic abundances compared to the solar values) = 0.14 $\pm$ 0.10 for Fe. A further result is that the line of sight microturbulence velocity component ζ_μ hardly varies with depth and equals 5.4 km s$^{-1}\pm$ 0.7.

INTRODUCTION

In the framework of a study of the motion fields in the atmospheres of super- and hypergiants close to the HD limit, we have re-determined the microturbulent atmospheric motion field of the supergiant η Leo. We thought that it might be useful to re-investigate Wolf's observational material (from which we used the equivalent width data $W_{\rm obs}$ of 320 spectral lines: 118 Fe, 81 TiII, 62 CrII, and other elements) because we want to study the depht dependence of the line-of-sight microturbulence velocity component, by making use of a new method for determining the average optical depth to which the observed microtubulence refers. This depth-dependence is known to be sensitive to the adopted model parameters $T_{\rm eff}$, log g and the abundance.

ANALYSIS USING VARIOUS ELEMENTS

A full description of the method to determine directly $T_{\rm eff}$, log g, ζ_μ and the abundance from a given set of $W_{\rm obs}$ can be found in Achmad et al. (1991a). This *method of linearization* is based on the requirement that the calculated equivalent widths $W_{\rm cal}$ of all lines, for a choosen set of stellar parameters, should be roughly equal to their $W_{\rm obs}$.

Starting from Wolf's parameters $T_{\rm eff}$=10400 K, log g=2.05 cm s^{-2}, choosing ζ_μ = 3.5 km s^{-1} and assuming solar abundance for all elements, we derived improved values in successive approximations using Kurucz models (1979). After 4 iterations we conclude that the best model atmosphere for η Leo, using various elements is: $T_{\rm eff}$ = 10700 K $\pm$ 200; log g = 1.8 $\pm$0.15; the average ζ_μ -value over the depth of the atmosphere is 5.3 km s$^{-1}\pm$ 0.4 and $\Delta\log Z$ = 0.23$\pm$ 0.12.

These photospheric parameters are used to determine the 'average depth of formation' of each line, according to the method of Achmad (1991b) (cf. the present proceedings), together with its ζ_μ -value, by varying the $W_{\rm cal}$ until it equals its $W_{\rm obs}$, keeping the other model parameters constant. Fig.1 shows a plot of the ζ_μ -values against the Rosseland mean optical depth for this model. We also plot the error bars on these values, assuming an average error of 10% in the observations of the equivalent widths. From this graph we find that there is no significant depth dependence of ζ_μ.

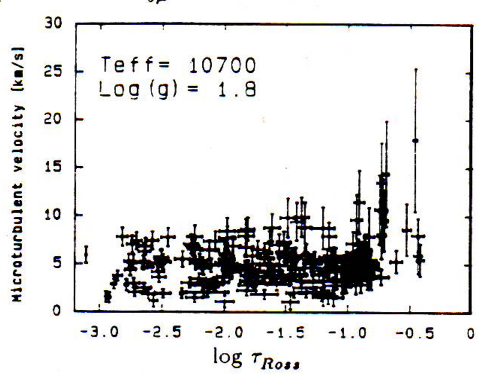

Figure 1: ζ_μ against Rosseland mean optical depth for the Kurucz model with $T_{\rm eff}$ = 10700 K and log g = 1.8.

However, for this model we find that different chemical species can have different mean values of ζ_μ at the same optical depth. For example, the mean value of ζ_μ over the depth of formation of ionized Vanadium lines is $<\zeta_\mu>$ = 2.8 instead of 5.3, which indicates that the abundance of VII in η Leo is lower than the $\Delta\log Z$ = 0.23 adopted for this model. Moreover, the difference between $<\zeta_\mu>_{\rm FeI}$ = 3.9 and $<\zeta_\mu>_{\rm FeII}$ = 5.2 is another indication that our model is not determined accurately enough.

ANALYSIS USING ONLY IRON LINES

Repeating the previous analysis, but now only using a set of 118 Fe lines, we find for the *best iron-model* parameters: $T_{\rm eff}$ = 10300 K $\pm$370, log g = 1.9 $\pm$ 0.4,

$\zeta_\mu = 6.6 \pm 0.7$ and $\Delta \log Z_{Fe} = 0.10 \pm 0.13$. Since these parameters are in good agreement with those of the previous model, we conclude that it is reasonable to derive the optimal model parameters by using only one chemical species.

In fig.2 the ζ_μ -values are plotted for 63 retained Fe-lines. Fig.3 shows that the averaged value of ζ_μ stays constant throughout the atmosphere for neutral and singly ionized lines. This is calculated using a smoothing function and taking into account the weights of the various values as determined by the error on each line. Still there remains a difference in the mean values $< \zeta_\mu >_{FeI} = 7.3$ and $< \zeta_\mu >_{FeII} = 6.1$.

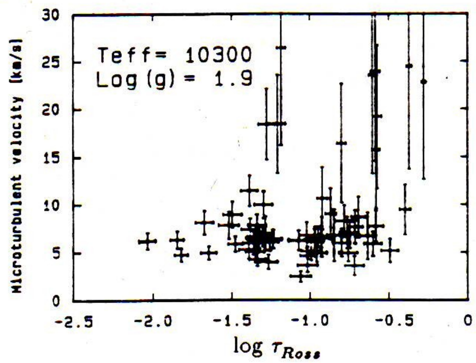

Figure 2: ζ_μ against Rosseland mean optical depth for the Kurucz model with $T_{eff} = 10300$ and log $g = 1.9$.

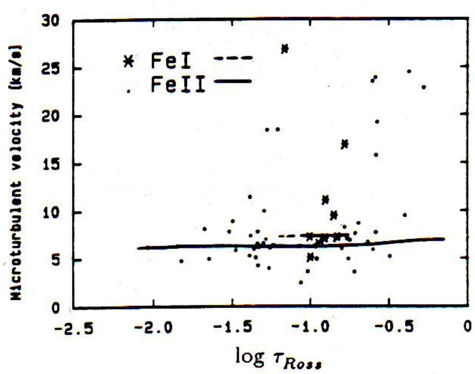

Figure 3: averaged ζ_μ for FeI and FeII for the model with $T_{eff} = 10300$ K against Rossland mean optical depth.

This difference dissapears when decreasing the T_{eff} of the iron model with only 100 K. In that case, $< \zeta_\mu >$ obtains a value of 5.38 for FeI and 5.35 for FeII, or $< \zeta_\mu >_{Fe} = 5.4$. This value is comparable with the value of 4.6 found by Przybylski (1969) using the vertical shift in the curve of growth for FeII lines. Notice that the log g -value is kept constant in this calculation.

In fig.4 we plot the averaged values for FeI and FeII throughout the atmosphere. Here, the dashed line for FeI with log τ_{Ross} between -1.5 and -0.8, is at the same level as this for FeII.

Because we find $T_{eff} = 10200$ K from decreasing the effective temperature (with 100 K) of the model which was found by iteration, we also have to redetermine the model abundance (assuming a constant $\zeta_\mu = 5.4$). Hence, we find $\Delta \log Z_{Fe} = 0.14 \pm 0.10$ which is also in good agreement with the value of 0.18 derived by Wolf.

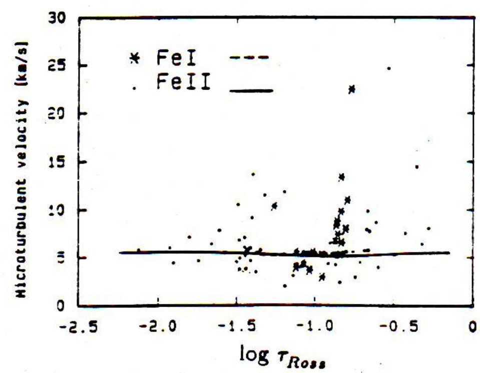

Figure 4: averaged ζ_μ for FeI and FeII for the model with $T_{eff} = 10200$ K against Rosseland mean optical depth.

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