IRON LINES AND SURFACE GRAVITY DETERMINATION FOR τ CETI

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ABSTRACT. We present a spectroscopic analysis for the gravity determination of τ Ceti on the basis of a new and high quality set of data. The iron lines are studied by using the Oxford oscillator strengths. The results are compared with those obtained with "solar" oscillator strengths. Non-LTE effects seem to be important in this star. The FeI at λ 526.955 nm line is used to apply the Blackwell and Willis (1977) method to determine the surface gravity. The derived log g is 4.70±0.1.

1. OBSERVATIONS AND ANALYSIS

The observations were made in October 1985 at ESO using CAT+CES and a Reticon detector with a resolving power of 80000. Reductions were carried out using the ESO IHAP system. Where possible the lines were analysed using the Oxford oscillator strength (Blackwell et al., 1986 a, and references therein). For high excitation lines where no laboratory measurements of adequate precision are available, we have determined "solar" oscillator strengths from the solar flux spectrum, in a similar way to Smith et al. (1986). The sources for the damping constant values are the works by Simmons and Blackwell (1982) and Gurtovenko and Kondrashova (1980). For the damped line used to determine the surface gravity, γ_H/N was obtained by adjusting its profile in the solar flux spectrum (Kurucz et al., 1984) to the synthetic one generated with the Holweger and Müller (1974) solar model.

In order to obtain the value for Teff we have applied the Infrared Flux Method (Blackwell et al., 1986 b and references therein), obtaining a value of 5250 K with a probable error of ± 50 K.

The equivalent widths were interpreted in terms of log (Agf) values by using an LTE code. For the entire analysis we have used model atmospheres generated by the MARCS suite of programs. The MARCS atmospheres are line-blanketed and flux constant atmospheres of the same type as those published by Bell et al. (1976).

The analysis to determine the microturbulence is analogous to the one used by Smith et al. (1986 and references therein). Thus, the microturbulence (ξ) and the abundance (A) of an element are obtained simultaneously from the function A=A(ξ) for a set of lines with a wide range in equivalent widths.

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In Figures 1 a, b and 2 a, b we present the behaviour for the FeI lines in τ Ceti and in the Sun, when their respective MARCS models were used. Figures b indicate the scatter in abundance as a function of ξ. We can observe that minima are sited at 1.12 and 1.19 Km s^{-1} for τ Ceti and the Sun respectively. In Figures 1 a, b the lowest excitation lines have not been considered for reasons discussed below.

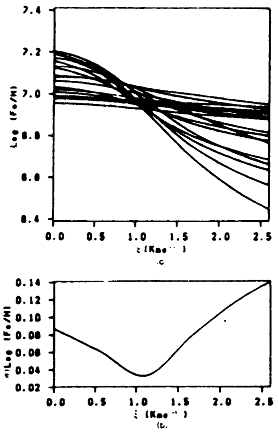

Figure 1

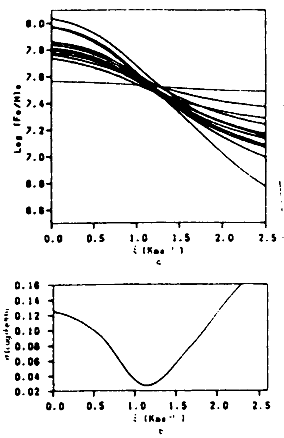

Figure 2

Figure 1 . Diagrams abundance-microturbulence for τ Ceti (a) for a set of iron lines with different equivalent widths. In the lower figure (b) the scatter in the abundance versus microturbulence is presented . In this figure we can observe how the minimum is relatively well defined at ξ=1.12 Kms^{-1}. These figures have been obtained by use of the MARCS model with parameters Teff=5250 °K, log g=4.20 and [Fe/H]=-0.40

Figure 2 . Same than in figure 1 for the Sun, using the solar MARCS model. Now the value of ξ which produces the minimum in abundance is 1.19 Kms^{-1}.

2. FeI LINES

When the iron lines with accurate oscillator strength (low excitation) were analysed a clear correlation between abundance and excitation was found. Lines with excitation higher than 3 eV were analysed by use of "solar" oscillator strengths. In this case, the absolute abundance is not directly significant but the abundance relative to the Sun is reliable. We observed also an important difference in the relative abundance value when comparing with the lower excitation lines. These effects are unlikely to be explained by errors in the atomic parameters, equivalent widths or effective temperature taking into account the estimated errors for these magnitudes. An explanation for this could be non-LTE effects in the solar photosphere. Athay and Lites (1972) pointed out that such effects could be important for the FeI and FeII in the solar photosphere. However, Rutten and Kostik (1982) have found that the Holweger and Müller (1974) model corrects these effects as well as the Bell et al. (1976) model. As also in this case reasonable changes in the model parameters do not explain the effect, we must think of non-LTE in excitation in τ Ceti. For all these reasons the value for the iron abundance remains more uncertain than expected from the quality of the atomic and observational data used here. Thus we consider

$$\log (\mathrm{Fe/H}) = 7.00 \pm 0.07 \quad \text{and}$$
$$[\mathrm{Fe/H}] = -0.53 \pm 0.07$$

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3. GRAVITY DETERMINATION

For the surface gravity determination we applied the Blackwell and Willis (1977) method to the FeI λ 526.955 line, which is strongly broadened by collisions. In this case, abundance is obtained from lines with similar excitation, in order to minimize non-LTE effects. When the MARCS solar models are used, the best fit is found for log g=3.94. Other authors have also found important differences in the log g values when using different solar models (Ruland et al., 1980). This shows the difficulty in absolute g determinations. For τCeti we found the best adjustement with the MARCS model with log g=4.20 (Figure 3). When the log g value obtained for τ Ceti si normalized to the proper solar one, we obtain log g=4.70 ± 0.10.

The log g value obtained disagrees with the one obtained by Smith and Drake (1987) from the calcium line λ 616.217 nm (log g=4.50± 0.1). Partially, this can be explained by the difference in the effective temperature assumed. On the other hand it is also noticeable that Bell et al. (1985) obtained a difference of 0.1 dex in the log g value for Arcturus when this was obtained from the CaI λ 616.217 nm and from the FeI λ 526.955 lines in the same sense as obtained here.

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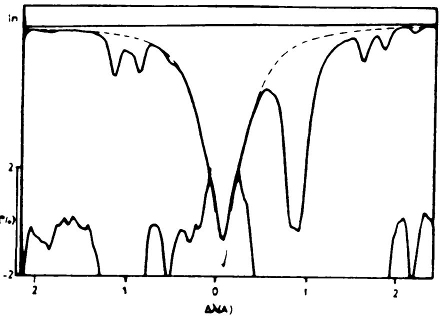

Figure 3 . Best fit for the observed spectrum for τCeti, assuming Teff=5250°K with the MARCS models. The log g value was 4.20. Continuum line represents the observed line and discontinuum one indicates the synthetic profile. The lower scale indicates the difference in percentage between both types of profiles.

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