A Comparison of Methods for Photospheric Abundance Determinations in K-Type Stars

L. Affer[1], G. Micela[1], T. Morel[1], J.S. Forcada[2], and F. Favata[2]

[1] INAF-Osservatorio Astr. di Palermo, Piazza del Parlamento 1, Palermo, Italy
[2] Astrophysics Division - Research and Science Support Department of ESA, ESTEC, Postbus 299, NL-2200 AG Noordwijk, The Netherlands

Abstract. We have performed a detailed abundance analysis of six inactive K-type stars using high-resolution optical spectra. We have used three different techniques and compared the results obtained in order to establish their respective merits and faults. The two spectroscopic methods give consistent results suggesting that non-LTE effects are small, whereas the 'mixed' spectroscopic-photometric method leads to photospheric parameters and abundances systematically lower than those obtained with the other two. We have also determined the stars' positions in H-R diagrams and made a comparison between the gravities derived from the ionization equilibrium of the iron lines and from the evolutionary tracks: the agreement is reasonably good.

1 Observations

We have observed three subgiants HD 23249 (K0), HD 198149 (K0), HD 222404 (K1) and three dwarfs HD 10780 (K0), HD 4628 (K2), HD 201091 (K5), on 2002 November 28 and 29, with the high-resolution cross-dispersed echelle spectrograph SOFIN, mounted on the Nordic Optical Telescope (NOT). They are in the solar neighbourhood ($\leq$ 15 pc), are very bright ($V \leq 6$) and have modest projected rotational velocities ($v \sin i \leq 4$ km s^{-1}) to limit blends between spectral lines. They also do not present any evidence for emission (or a moderate one, as in the case of the three dwarfs) in the core of Ca II H and K lines.

2 Methods of Analysis

The atmospheric parameters and metal abundances were determined using the measured equivalent widths (EWs) and a standard local thermodynamic equilibrium (LTE) analysis with the most recent version of the line code MOOG. We used a grid of Kurucz ATLAS9 atmospheres computed without the overshooting option and with a mixing length to the pressure scale height ratio $\alpha = 0.5$. We have determined the abundance ratios with respect to iron of 12 elements. The reader is referred to [1] for further details.
Three different iterative methods were used for the analysis.
Method 1: The effective temperature was derived from the excitation equilibrium of the Fe I lines and the surface gravity from the ionization equilibrium of the iron lines.
Method 2: It follows a similar approach as for Method 1, but discards the Fe I

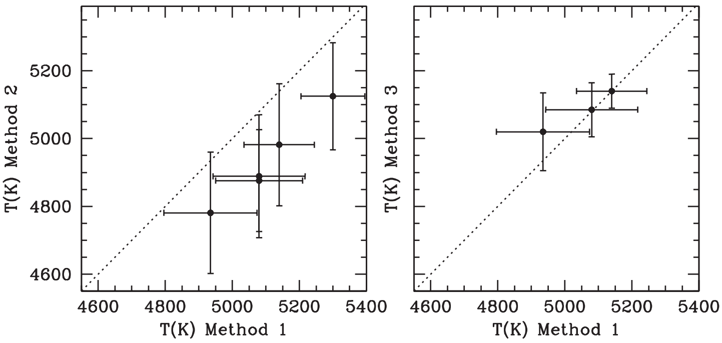

Fig. 1. Comparison between the temperatures obtained by methods 1 and 2 (*left-hand panel*) and by methods 1 and 3 (*right-hand panel*).

low excitation potential transitions (which are potentially affected by non-LTE effects) and relies on the $B-V$ colour index to determine the temperature [2,3]. *Method 3:* It relies on the detailed fitting of the 6162 Å Ca I line to derive the surface gravity, using the same restricted line list as for Method 2. We have used the excitation equilibrium to determine the effective temperature.

2.1 Comparison of the Methods

Methods 1 and 3 give consistent results for the program stars. The good agreement between the atmospheric parameters and chemical abundances derived suggests that the Fe I low excitation potential transitions are not significantly affected by non-LTE effects (at least for the subgiant stars, for which Method 3 has led to convergent solutions). The second method leads to systematically lower $T_{\rm eff}$ (Fig. 1) and $\log g$ values with respect to the first one, and a similar trend is shown by the chemical abundances (with the exception of the oxygen abundance).

3 Evolutionary Status

We have determined the positions of our stars in H-R diagrams for the appropriate Fe and [α/Fe] abundances, using $T_{\rm eff}$ obtained by Method 1 and the absolute magnitudes, $M_{\rm v}$, derived from Hipparcos parallaxes. The good agreement between the gravities obtained from the evolutionary tracks ([4]) and those from Method 1 suggests that non-LTE effects are unlikely in Method 1.

References

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