Abstract. LTE/non-LTE boundary has been derived from the analysis of the flux data from atmospheric models. The derived border line seems to be like a reasonable extension at low log g’s of the Kudritzki line (Kudritzki, 1976), derived in a similar way. A discrepancy is evidenced between boundaries based on photometric analysis and the ones based on physical considerations.

1. Introduction

High-temperature model-atmospheres have become an important tool in the past years, with the incoming of space UV astrophysics (see, e.g., Holm and Cassinelli, 1977; Conti and Frost, 1977; Shipman et al., 1977; Panek, 1977). Comparison between theoretical outputs and experimental data is, in fact, the usual way to derive the physical and chemical parameters of the observed stars. As an example, the effective temperature ($T_{\text{eff}}$) is often determined by matching the theoretical energy distribution or the Johnson theoretical color indices, to the experimental scans or, respectively, to the measured $U - B$, $B - V$. But, at high temperatures or low log g’s, the simplifying assumption of the local thermodynamic equilibrium (LTE), which is used in the computation of most model atmospheres, falls down. So, we may gather wrong stellar parameters, by matching the data to the energy distribution from a wrong model. We need then to establish a boundary, limiting the region where LTE models can match still satisfactory the observations, in order to compute models as close as possible to the actual ‘status’ of the stellar atmospheres. Such a kind of border line has already been quoted (e.g., Greenstein and Sargent, 1974; Kudritzki, 1976), but only as an estimate on physical quantities (the former), or in a limited region of the ($\log T_{\text{eff}}$, log $g$) plane (the latter).

In this paper we want to derive this border line from the differences we found by comparing the color indices and the bolometric correction (BC) from LTE and non-LTE (NLTE) model atmospheres.

We have used the energy distributions from Mihalas models (Mihalas, 1972). So our results are referred to a standard solar chemical composition. We have to stress this point, as the boundary depends on the $N(\text{He})/N(\text{H})$ ratio (Kudritzki, 1976).

For the physical treatment of the NLTE, which is beyond the scope of the present work, we refer to the paper by Mihalas (1972).
2. Derivation of the Johnson Color Indices and of the Bolometric Correction

The flux distributions of LTE and NLTE Mihalas models (Mihalas, 1972) have been used in order to derive the $U - B$, $B - V$ color indices and the bolometric correction. The wavelengths range from $\sim 30\mu$ up to $\sim 114\,\text{Å}$ for the hottest models, with a variable wavelength step. The temperature step is 2500 K when $15\,000\,\text{K} \leq T_{\text{eff}} \leq 40\,000\,\text{K}$, and $5000\,\text{K}$ when $40\,000\,\text{K} \leq T_{\text{eff}} \leq 55\,000\,\text{K}$. The gravity ranges from $\log g = 2.5$, for the lowest temperatures, to $\log g = 4.5$. These temperature and gravity ranges enable us to establish the scope of this research.

No blanketing is included in the model computation.

The $(U - B)_1$ and $(B - V)_1$ color indices have been computed by means of the UBV filter response curves by Matthews and Sandage (1963) for air mass one. The improved method by Wright and Argyros (1975) of the double parabolic interpolation (Kurucz, 1970) and the trapezoidal rule have been used throughout, in order to perform the integration on the photometric bands.

The color index differences have been computed by means of the differences

$$\Delta(U - B) = 0.921 \, (U - B)_{1,\text{NLTE}} - (U - B)_{1,\text{LTE}},$$
$$\Delta(B - V) = 1.024 \, (B - V)_{1,\text{NLTE}} - (B - V)_{1,\text{LTE}},$$

where the extinction constants are those reported by Matthews and Sandage for one air mass. Notice that, as we are dealing with color-index differences, the uncertainty in the zero point constant determination is avoided.

Even more simplified are the bolometric correction differences. They are given by

$$\Delta(BC) = -2.5 \frac{\int F_{\lambda,\text{NLTE}} \, S^0_{P_{\lambda}}(\lambda) \, d\lambda}{\int F_{\lambda,\text{LTE}} \, S^0_{P_{\lambda}}(\lambda) \, d\lambda},$$

where $S^0_{P_{\lambda}}(\lambda)$ is the normalized zero air mass sensitivity function in the $V$-band (Matthews and Sandage, 1963). Either the zero point constant, or the total flux ($\int F_{\lambda} \, d\lambda$) are then deleted.

In conclusion, no matching with the scans of any observed star (usually $\alpha$ Lyr) was needed, but only the theoretical flux distributions and the filter response curves were required to perform the comparison.

3. The Results and Discussion

In Table I we report the $(\log g, \log T_{\text{eff}})$ loci where the NLTE-LTE differences from the $U - B$, $B - V$ rise over 0.01 m, which is a reasonable photometric error for the continuum quantities (Greenstein and Sargent, 1974). A similar tabulation for the bolometric correction (where the differences increase above 0.1 m) and for the Eddington flux at $1/\lambda = 1.7559\,\mu^{-1}$ (where the differences are greater than 5%) is shown in Table II. The Eddington flux is also taken from the paper by Mihalas.

For all the differences we have considered the absolute values.