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Line-blanketing effects in atmospheres of O-type stars

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Abstract. Line-blanketing effects in atmospheres of O-type stars are studied based on models computed with the non-LTE spherically expanding code CMFGEN (Hillier & Miller 1998). We show that the inclusion of metals leads to a reduction of the effective temperature scale by ~ 1500 K at spectral type O9.5, up to ~ 4000 K at spectral type O3. This change of the $T_{\rm eff}$ scale implies a reduction of the luminosity by ~ 0.1 dex and a decrease of the ionising flux by $\sim 50\%$ for a given spectral type.

1. Introduction

The inclusion of metals in model atmospheres of O-type stars (line-blanketing effect) is a complex task. Various attempts have been made since the work of Abbott & Hummer (1985), *e.g.*, by Schaerer & Schmutz (1994), Schmutz (1998), Hubeny *et al.* (1998), and Herrero *et al.* (2000). Hillier & Miller (1998) with a super-level approach and Pauldrach *et al.* (2001) with an opacity sampling method made significant improvements. We show here the results of a quantitative study of line-blanketing effects in O-type dwarf models computed with the code CMFGEN (Hillier & Miller 1998). A full account of our study can be found in Martins *et al.* (2002).

2. Results

The inclusion of metals in model atmospheres of O-type dwarfs leads to a modification of both the atmospheric structure and the emergent spectrum. In the inner part, photons are backscattered towards the inner atmosphere so that, in order to fullfill the flux, the temperature rises (Figure 1) which increases the ionisation, and hence modifies the strength of the He classification lines. This leads to a cooler $T_{\rm eff}$ scale compared to previous calibrations based on H-He analysis (Figure 1). As a consequence, the luminosity is also reduced by ~ 0.1 dex. In the outer part of the atmosphere, the blocking of the EUV flux by metal opacities leads to a reduction of the ionisation, and escape of photons through metallic lines decreases the temperature (see Martins *et al.* 2002 for details).

Another important effect of line blanketing is the reduction of ionising fluxes. This is due to two effects: (*i*) the inclusion of new bound-free opacities from metals blocks the EUV flux; and (*ii*) the cooler $T_{\rm eff}$ scale implies a smaller number of ionising photons for a given spectral type. For dwarfs stars,

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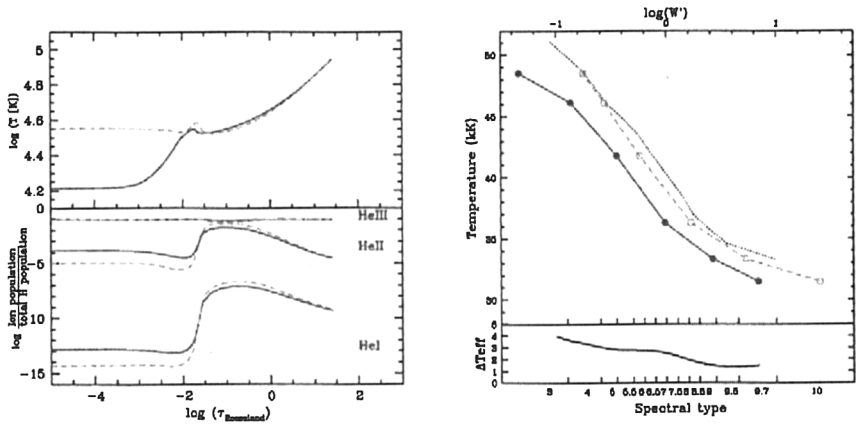

Figure 1. Temperature and He-ionisation structure (*left*) and $T_{\rm eff}$ scale (*right*). Solid line is for line-blanketed models; dashed line is for pure H-He models. The $T_{\rm eff}$ scale of Vacca *et al.* (1996) is also shown by a dotted line.

a reduction of $\sim 50\%$ of the ionising flux is found. This has important consequences for the study of H II regions.

3. Conclusion

The reduction of the $T_{\rm eff}$ scale due to line blanketing predicted by different authors (Abbott & Hummer 1985; Schaerer & Schmutz 1994) has been studied quantitatively for O-type dwarfs. Our results are in agreement with recent analyses of individual stars, *e.g.*, by Hubeny *et al.* (1998), Fullerton *et al.* (2000), Crowther *et al.* (2002), and Herrero *et al.* (2002).

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