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# New generation model atmospheres for chemically peculiar stars

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**Abstract.** The atmospheric structure of chemically peculiar stars deviates from that of normal stars with similar fundamental parameters due to unusual chemistry, abundance inhomogeneities and the presence of strong magnetic field. These effects are not considered in the standard model atmospheres, possibly leading to large errors in stellar parameter determination and abundance analysis. To resolve this problem we used the state-of-the-art opacity sampling model atmosphere code `LLmodels` to calculate a comprehensive grid of new generation model atmospheres for magnetic CP stars. This grid covers the whole parameter space occupied by SrCrEu and Si-peculiar stars, taking into account the characteristic temperature dependence of the chemical abundances. Here we present the first results of our model atmosphere calculations.

**Key words:** stars: atmospheres – stars: chemically peculiar

## 1. Model atmosphere calculations

To calculate realistic models of chemically peculiar stars we have used a 1-D, LTE, hydrostatic model atmosphere code `LLmodels` (Shulyak. *et al.* 2004). This code allows one to treat the line opacity without simplifying approximations and in this way accurately estimate how modification of the line opacity due to anomalous abundances, chemical stratification or the presence of strong magnetic field affects stellar atmospheres.

Our calculations cover the $T_{\rm eff}$ range between 6500 and 18 000 K with a step of 250–500 K, and the $\log g$ range of 3.25–4.5 dex with a step of 0.25 dex. For $\log g = 4.0$ models we have performed additional calculations including a 5 kG magnetic field, using the method described by Kochukhov *et al.* (2005). Individual abundances of 41 elements were adopted based on the results of modern chemical composition analyses of the SrCrEu and Si-type CP stars. For Ca, Si, Cr, Fe and several other elements we include the empirical temperature dependence of the element concentrations (Ryabchikova, 2005). The line lists are extracted from the VALD database (Kupka *et al.*, 1999). The Ap-star model grid is complemented with a grid of solar composition models, calculated for an extended range of atmospheric parameters ($6000 - 20\,000$ K in $T_{\rm eff}$ and $2.5 - 4.5$ dex in $\log g$).

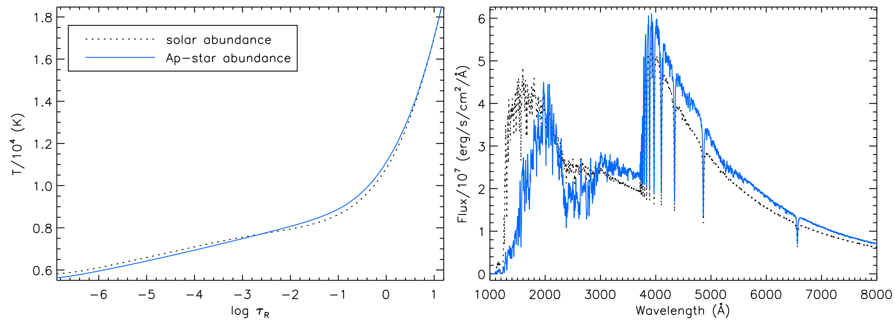


**Figure 1.** Results of the model atmosphere calculations for a star with $T_{\rm eff} = 10\,000$ K and $\log g = 4.0$. The $T$-$\tau$ relations (lef) and flux distributions (right) are presented for a model with solar abundances and for a model with the Ap-star abundance table.

## 2. Results

For each Ap-star model atmosphere we have examined the deviation of the temperature stratification, flux distribution, hydrogen line profiles and photometric colors from those of normal composition model with the same parameters. Fig. 1 illustrates the impact of anomalous abundances on the atmospheric structure of an early-A star. In general, we find that

(i) peculiar abundances lead to 200–400 K increase of $T$ in deep layers and 100–200 K cooling of the upper atmosphere;

(ii) the impact of 5 kG magnetic field is negligible compared to that of the chemical composition anomalies;

(iii) fitting normal composition models to the hydrogen lines of Ap stars underestimates $T_{\rm eff}$ by $\approx 250$ K and $\log g$ by $\approx 0.25$ dex;

(iv) model fluxes of Ap stars are dominated by the energy redistribution from UV to visual and IR wavelengths; the bolometric corrections of Ap and normal stars differ systematically by $\leq 0.1$ mag;

(v) the usual photometric calibrations overestimate $T_{\rm eff}$ of Ap stars by 300–500 K.

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