Effective temperatures of CP stars

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Abstract. A new method of $T_{\rm eff}$ determination for CP stars is proposed. The method is based on the fact that the slope of the energy distribution in the Balmer continuum near the Balmer jump is identical for "normal" main sequence stars and for CP stars with the same $T_{\rm eff}$. It is shown that the $T_{\rm eff}$ of CP stars derived by this method are in good agreement with those derived by other methods.

Key words: chemically peculiar stars – fundamental parameters

1. Introduction

A review of the various methods of effective temperature determination for chemically peculiar (CP) stars shows once more the difficulty of deriving the $T_{\rm eff}$ of these stars. If one uses methods taking into consideration the blanketing effect, the temperature obtained is close to the effective one. In the infrared flux method (IRFM) first proposed by Blackwell & Shallis (1977), a monochromatic flux is measured in the infrared region to minimize the blanketing effect. The method proposed by Stępień & Dominiczak (1989) takes into account the blanketing effect as well. The photometric methods may be useful, since it is possible to apply a correction to the color (or model) temperature and to give relatively good estimates of $T_{\rm eff}$ (Hauck & North 1993). Another way is to use an observational parameter which is not affected by peculiarities and can be applicable both to the "normal" main sequence stars and to the CP stars. The Balmer continuum slope near the Balmer jump ($\Phi_{\rm u}$) can be a useful tool for determination of $T_{\rm eff}$ for CP stars (Sokolov 1995). The determination of the effective temperatures of CP stars using the $\Phi_{\rm u}$ is discussed.

2. The method description

It is well known that the first order difference between energy distribution of "normal" main sequence stars and peculiar stars is caused by extra blocking of the flux in the far-UV and the redistribution of it in the longer wavelengths. The method presented here assumes the existence of a wavelength region, between the far-UV and visual regions, where the energy distribution is the same for "normal" and for CP stars. The comparison of the observed energy distribution with the best fitting model for twelve CP stars given by Stępień & Dominiczak

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(1989), supports this assumption and shows that Φ_u is identical both for the observed energy distribution of CP stars and for the models (see Fig. 2 of Stępień & Dominiczak 1989). From the theoretical point of view, the computations carried out by Leckrone et al. (1974) and by Muthsam (1978, 1979) show that there exists a wavelength λ_{tr} such that for $\lambda < \lambda_{tr}$ the flux of a CP star is lower than that of a normal star with the same T_{eff}, whereas for $\lambda > \lambda_{tr}$ it is enhanced. Note that the location of λ_{tr} is in the Balmer continuum near the Balmer jump, which is used for the determination of T_{eff} (Sokolov 1995).

Based on the theoretical prediction, as well as on the fact that the Φ_u of models and CP stars is identical, this observational parameter is used to determine the T_{eff} of CP stars. The temperature calibration of B, A and F main sequence stars given by Sokolov (1995) is applied to the CP stars as well.

3. Results and discussion

The calibration curve described above was applied to 50 CP2 stars from the catalog of stellar spectrophotometry (Adelman et al. 1989) and to 18 CP2 stars from the Pulkovo spectrophotometric catalog of bright stars (Alekseeva et al. 1996). To test the validity of the proposed method of determination of T_{eff} for CP2 stars, the temperatures derived from Φ_u were compared with those derived from the IRFM, from the method of Stępień & Dominiczak (1989) and from the (B2-G) color index of Geneva photometry.

In the literature we found five papers concerning CP2 stars for which the effective temperature is derived using the IRFM. The values of T_{eff} derived from Φ_u are compared with those obtained by IRFM for 13 common stars (see Fig. 1a). One can see that the agreement appears to be very good. So, the mean effective temperature difference is $\Delta T_{eff} = T_{eff}(\Phi_u)$ - T_{eff}(IRFM) = 41±127 K, with a linear correlation coefficient $r = 0.972$, and $\alpha = 0.904$ for the slope of the regression line of $T_{eff}(\Phi_u)$ versus T_{eff}(IRFM).

Stępień & Dominiczak (1989) proposed a new method to determine the effective temperatures of CP2 stars. In order to have a wider sample of stars for the comparison, this method was applied to the model temperatures (T_M) obtained by Adelman (1985). The value of T_M was calculated as the average of T(PC) and T(BJ) for all stars of Table 2 of Adelman (1985). After that, this mean value of T_M was corrected for the blanketing effect by using Eq. 12 from the paper of Stępień & Dominiczak. The resulting temperatures (T_{eff}(S&D)) are compared with T_{eff} derived from Φ_u. Figure 1b gives a plot of $T_{eff}(\Phi_u)$ versus T_{eff}(S&D) for 47 common stars. Basically, there are no systematic differences between the two sets of data, as confirmed by the following results: $\Delta T_{eff} = 38 \pm 69$ K, $r = 0.952$, $\alpha = 0.965$.

In order to estimate photometrically the effective temperatures of CP2 stars the $(B2-G)$ color index was used. Figure 1c gives a plot of the T_{eff} derived from Φ_u versus $T_{eff}(B2-G)$ for the 59 common stars. One can see that there

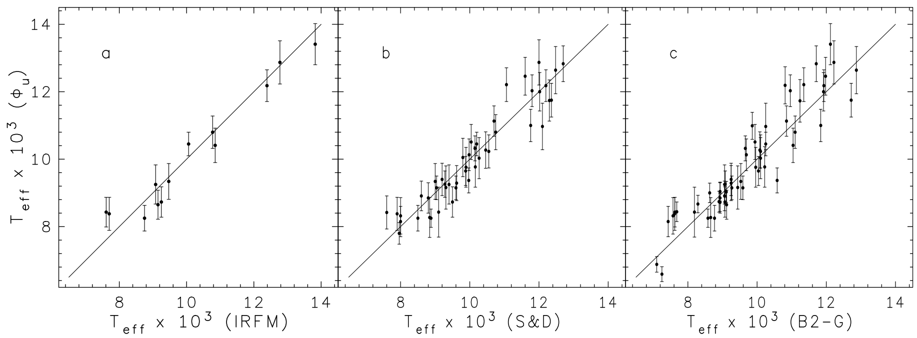

Fig. 1: Comparison of $T_{\rm eff}$ derived from $\Phi_{\rm u}$ with those derived by infrared flux method - (a), by the method proposed by Stępień & Dominiczak - (b) and from (B2-G) color index of Geneva photometry - (c).

is no systematic difference between the two sets of data, though the scatter of the points on Figure 1c is rather high (up to 1000 K), especially for the stars with $T_{\rm eff} > 9500$ K. For the stars in our sample we have $\Delta T_{\rm eff} = 102 \pm 76$ K, $r = 0.938$, and $\alpha = 0.975$.

Generally, there is no significant systematic difference between the temperatures derived from $\Phi_{\rm u}$ and those derived from fluxes by other methods. The temperature calibration derived for B, A and F main sequence stars is applicable to CP2 stars as well. The temperature derived from $\Phi_{\rm u}$ for CP2 stars may be identified with their effective one, because the influence of the stars's peculiarity on the Balmer continuum slope near the Balmer jump is negligible. In our study only CP2 stars were used, but this method can be extended to other types of CP stars, for which the blanketing effect is less pronounced: for them, the temperature derived from $\Phi_{\rm u}$ should then be even closer to the effective one.

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