THE BOLOMETRIC CORRECTION ($m_{\rm bol} - Hp$)

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ABSTRACT

By the use of model atmospheres fluxes computed with Kurucz's ATLAS9 code, we have investigated the behaviour of the computed bolometric correction of the Hipparcos Hp band, namely $BCHp = m_{\rm bol} - Hp$, with the basic physical parameters effective temperature, gravity and metallicity. The theoretical relations of $BCHp$ versus effective temperature($T_{\rm eff}$) are compared to empirical ones.

Key words: bolometric correction.

1. INTRODUCTION

It is well recognised that the Hipparcos photometric band Hp would be a better choice than the Johnson V magnitude for making use of a bolometric correction, on the grounds that (i) the Hp band is very wide, and therefore a better approximation of the total flux than the V band, and (ii) it is measured with a greater accuracy for most Hipparcos stars (see, e.g. Lampens et al. 1997). In this way we would consider the use of:

$$BCHp = m_{\rm bol} - Hp \qquad (1)$$

instead of:

$$BCV = m_{\rm bol} - V \qquad (2)$$

For this purpose, we have undertaken an extensive computation of BCHp, using grids of model atmospheres and fluxes computed with an up to date version of the Kurucz's ATLAS9 code (Kurucz & Castelli, 1996, private communication). The range of paramater values covered is: $T_{\rm eff}$ = (4000[250]8500), log g = (0.[0.5]5.0), $[M/H]$ = ($-$2.5[0.5]0.5), altogether about 1500 models.

2. COMPUTATION AND BEHAVIOUR OF BCHp

Starting from the Kurucz grids of models, for which the ratio of the mixing length to pressure scale height l/H_p = 1.25 remains unchanged, we recomputed all the models without the overshooting option, for the reasons explained in Van't Veer-Menneret & Mégessier (1996), Castelli et al. (1997) and Freytag (1996). Models and fluxes are computed using Opacity Distribution Functions (ODF) with respectively big and little wavelength intervals, and a microturbulence of 2 km s^{-1} in both cases. The monochromatic fluxes were then derived, and the signal S_{Hp} computed as:

$$S_{Hp} = \int_{330}^{900} \frac{H(\lambda)}{(hc/\lambda)} S(\lambda) {\rm d}\lambda \qquad (3)$$

with λ in nm; $H(\lambda)$ is the monochromatic flux and the factor hc/λ converts an energy/s in number of photons/s, what actually is counted by Hipparcos. The sensitivity curve $S(\lambda)$ is given in the Hipparcos Catalogue (ESA 1997). The integral is actually computed as a finite sum over each of the little λ intervals in the ATLAS9 ODF's, usually 2 nm excepted near the Balmer and Paschen jumps.

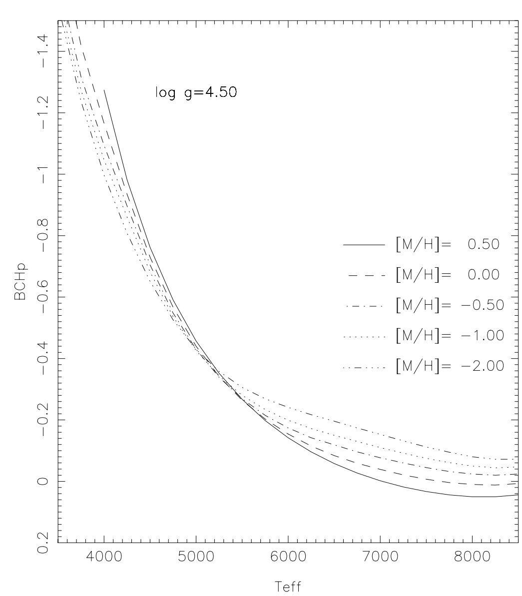

Figure 1. Effect of metallicity on $BCHp$ as a function of $T_{\rm eff}$, for a constant gravity of $\log g = 4.5$.

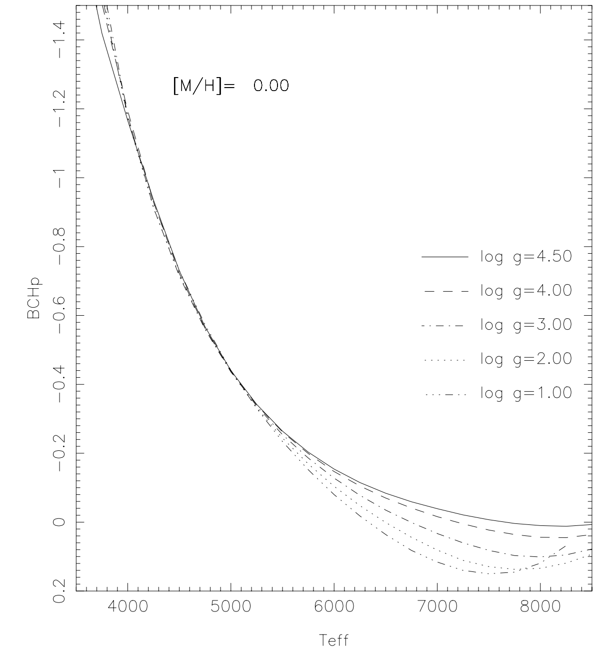

Figure 2. Effect of gravity for a given metallicity, here [M/H] = 0.00. The confluence of the curves, at this metallicity, between 4000 and 5200 K, could be due to the disappearance of the Balmer discontinuity.

The bolometric flux is a parameter of each model, following the basic relation:

$$F_{\rm bol} = \sigma T_{\rm eff}^4 \quad (4)$$

σ being the Stefan-Boltzman constant. The bolometric correction applicable to Hp was computed as:

$$BCHp = 2.5\log_{10}(S_{\rm Hp}/F_{\rm bol}) + C \quad (5)$$

where C is a constant, arbitrary for the time being, but which must be determined later, when comparison with observations are planned.

A first result, obtained in cancelling the hc/λ factor in (3), is that the energy collected in the Hp band can reach as much as 40 per cent of the total flux when the effective temperature is such that the Hp band is centred on the maximum of the energy distribution curve of the star, i.e. about 7500 K.

Figures 1 and 2 show respectively the effects of metallicity and of gravity with respect to $T_{\rm eff}$. The crossing (Figure 1) and the confluence (Figure 2) of the curves around $T_{\rm eff}$ = 5000 K is worth noting. The strange behaviour of the curve for $\log g$ = 1.0 at 8000 K is to be considered with caution, and could be due to some numerical artefacts.

3. COMPARISON WITH OBSERVED BCHp

We have used the large set of observed apparent bolometric magnitudes from Alonso et al. (1996), which covers a wide range of metallicity, and observed Hp magnitudes from Hipparcos. The constant C, in

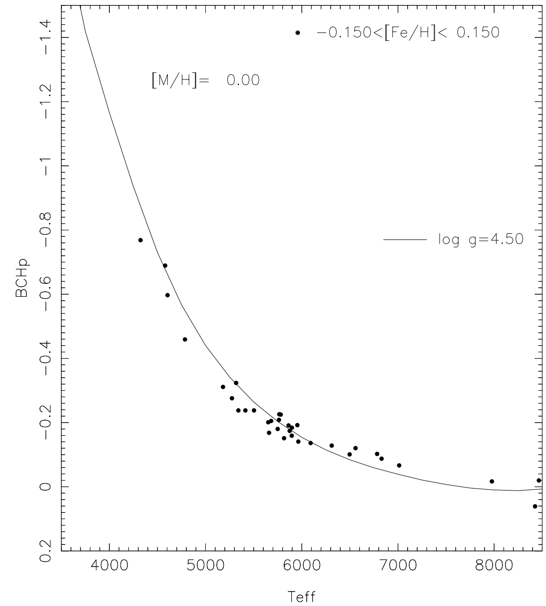

Figure 3. Fit made only with nearly solar metallicity main sequence stars.

Equation 5, was deduced from the best adjustment of the theoretical curves with the empirical $BCHp$ for stars for which we know both the apparent bolometric magnitude, the Hipparcos magnitude Hp and the effective temperature. This adjustment was done for solar metallicity main sequence stars of $T_{\rm eff}$ near 6000 K, along the $BCHp$ axis, and is shown in Figure 3.

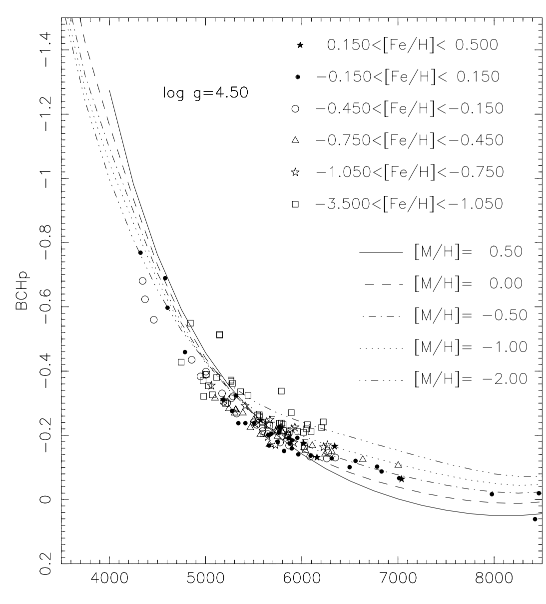

Figure 4. Comparison, with the set of stars in the Hipparcos programs of the authors, after we have fixed the value of C in such a way that dwarf stars of normal chemical composition and effective temperature near 6000 K match in ordinate.

Figure 4 shows the comparison for main sequence stars of different metallicities. Unfortunately we know from our Hipparcos programs the *Hp* magnitudes of very few subgiant or giant stars.

4. CONCLUSION

The examination of Figure 4 shows that, qualitatively, the trends predicted by the computations are present in the observations, but that quantitatively the fit is not everywhere satisfactory. The crossing of the theoretical curves around 5000 K appears to be present in the observations. A better appreciation of this point will become possible when the complete set of Hipparcos *Hp* magnitudes will be available.

The understanding of the behaviour of *BCHp* with metallicity and gravity requires a detailed analysis of the sensitivity of the flux profile (such as the Balmer and Paschen lines and discontinuities, line wings, molecular bands, and so on).

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