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Eclipsing binaries as a test for synthetic photometry

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Abstract. Narrow band photometry is a useful tool to characterize large numbers of stars, but observed colors and indices must be connected to astrophysical parameters by synthetic photometry. We present synthetic H_β indices calculated from 1D model atmospheres implementing different convection treatments. The calculated indices are transformed to the standard system using observed medium-resolution spectra. We test the synthetic photometry with observed indices of eclipsing binary systems. The computed indices agree with the observed ones up to an amount expected from the observational errors, the accuracy of the atmospheric parameters, and computational uncertainties.

Keywords. Stars: atmospheres, techniques: photometric, binaries: eclipsing

1. Introduction

Narrow band photometry is a useful tool to characterize large numbers of stars, but observed colors and indices must be connected to astrophysical parameters by synthetic photometry. We present synthetic H_β indices calculated from 1D model atmospheres implementing different convection treatments. Several different grids of stellar atmosphere models for B to K dwarfs and giants at a range of metallicities have been used: **CGM** and **MLT**(α, y) models from Heiter *et al.* (2002), **LL** models from Shulyak *et al.* (2004) with CM and MLT convection treatment, MARCS models from Gustafsson *et al.* (2003, **M**), and ATLAS9 models from Castelli & Kurucz (2006, **CK**). High-resolution synthetic spectra have been calculated with the SYNTH3 code (**S3**, see Piskunov & Kochukhov 2002) or as included in the model atmosphere codes above. Transmission functions for the β filter set have been taken from Crawford & Mander (1966) as shown in Fig. 1 (thick black lines).

2. Transformation to standard system

The calculated indices are transformed to the standard system using observed medium-resolution spectra. Instrumental indices (β_{Inst}) have been calculated for 414 A, F and G stars and 95 O and B stars using spectra from Valdes *et al.* (2004). Standard indices (β_{Std}) have been taken from from Hauck & Mermilliod (1998). Linear regression resulted

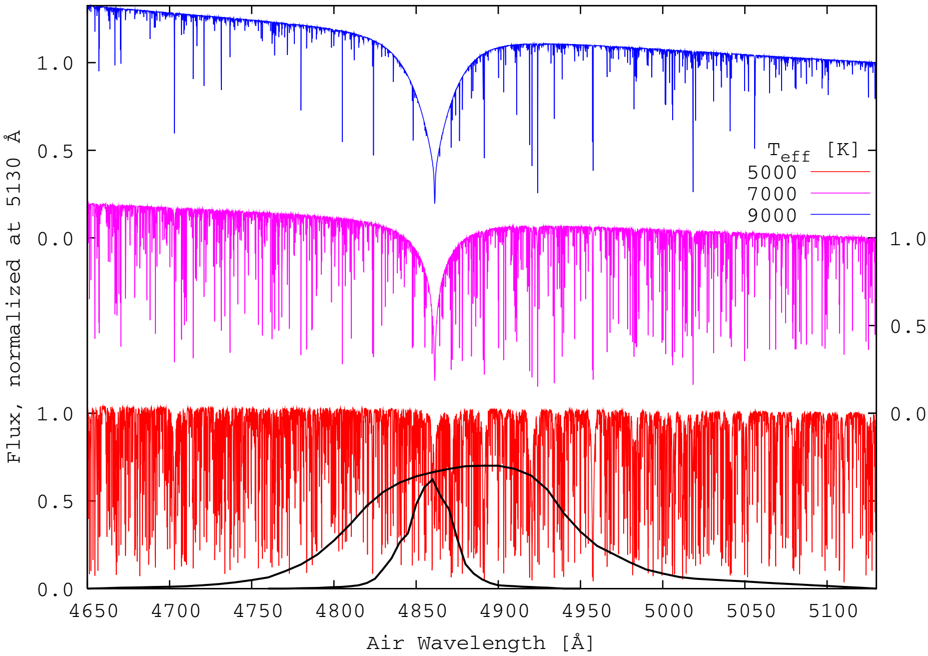

Figure 1. Synthetic fluxes (LL models, CM) for $T_{\rm eff} = 5000$ K (bottom), 7000 K (middle), 9000 K (top), $\log g = 4.0$, $[M/H] = 0.0$ and $\xi_{\rm t} = 2.0$, and β filter transmissivity.

Table 1. Differences in β values due to differences in model structure for $\log g = 4.0$, $[M/H] = 0.0$ and $\xi_{\rm t} = 2.0$.

$T_{\rm eff}$	MLT(1.2,0.5) −CGM	MLT(1.5,0.076) −CGM	LL/MLT −LL/CM
5000	−0.002	−0.001	−0.003
6000	−0.008	−0.004	−0.007
7000	−0.013	−0.007	0.000
8000	−0.004	−0.001	0.004

in the following two transformation equations (the errors of the coefficients are given in parenthesis):

$$\beta_{Std} = 0.159(10) + 1.366(6) \cdot \beta_{Inst} \quad \text{(A,F,G)}$$

$$\beta_{Std} = 0.288(24) + 1.303(13) \cdot \beta_{Inst} \quad \text{(O,B)}$$

The variation of β with parameters $T_{\rm eff}$, $\log g$ and $\xi_{\rm t}$ (microturbulence) is very similar for all metallicities. All β values increase slightly towards higher metallicity.

3. Discussion and conclusions

Differences in model structure due to different convection treatment lead to the differences in β values shown in Table 1 for $\log g = 4.0$, $[M/H] = 0.0$ and $\xi_{\rm t} = 2.0$.

We test the synthetic photometry with observed indices of eclipsing binary systems. Figure 2 illustrates that the computed indices agree with the observed ones up to an amount expected from the observational errors, the accuracy of the atmospheric parameters, and computational uncertainties.

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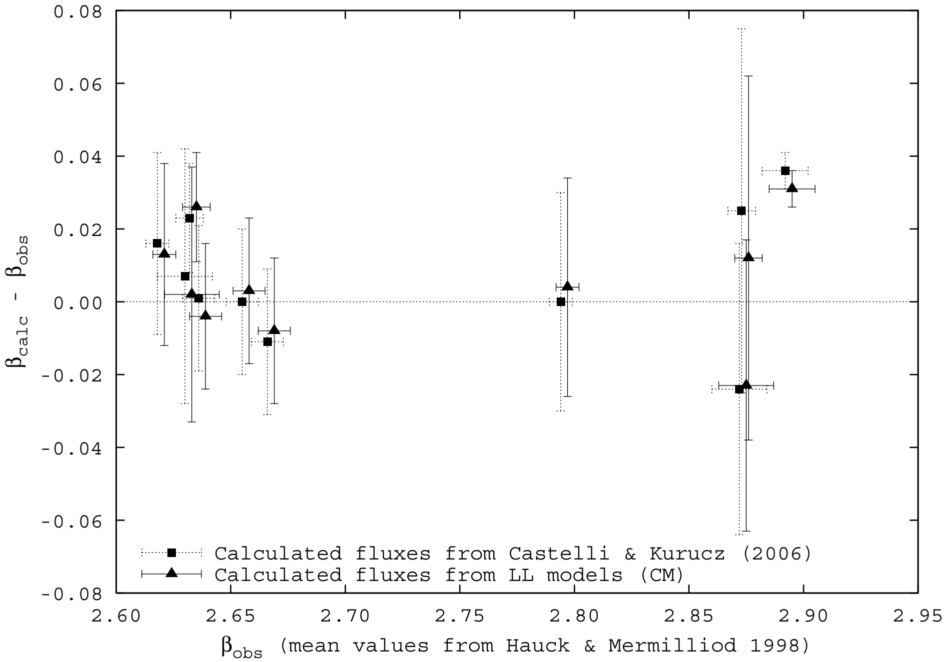

Figure 2. Calculated and observed β indices for ten binary stars from Smalley *et al.* (2002). Triangles have been shifted to the right by 0.003 for better visibility.

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