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Limb-darkening coefficients for the purpose of pulsation mode identification for A-F stars.

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Abstract. Limb-darkening coefficients are computed from a set of model atmospheres with: a solar chemical composition, 6000 $K \leq T_{eff} \leq$ 8500 K ($\Delta T_{\rm eff}$=250 K), 2.5 $\leq logg \leq$ 4.5 ($\Delta \log g$=0.1) and a microturbulent velocity of 2 km/s. Convection is included assuming either the turbulent convection approach of Canuto et al. (1996) or the classical mixing length prescription with α = 0.5 and 1.25. Four limb-darkening laws have been used: quadratic, cubic, square root and the one of Claret (2000). We compare the ATLAS 9 intensities and the ones computed from these laws. We find that Claret's law is the best law for almost all the models, independently of the convection prescription used.

Key words. Stars: atmospheres – Stars: oscillations

1. Introduction

Multicolor photometry is used for oscillation mode identification in variable main sequence stars such as Delta Scuti stars (e.g. Garrido 2000). These methods involve precise computation of oscillation amplitudes and phases which imply accurate computation of colors and limb-darkening coefficients (LDC) and their partial derivatives with respect to $\log T_{\rm eff}$ and $\log g$. We present in this paper LDC computed from up-to-date model atmospheres (see Heiter et al. (2002)) using the non-linear law suggested by Claret (2000) for the Strömgren and Geneva photometric systems. For the Strömgren system, we compare these LDC with the ones using simpler laws presented in Barban et al. (2003) (hereafter B03).

2. Limb-darkening coefficients

LDC have been computed as in B03 from model atmospheres with a solar chemical com-

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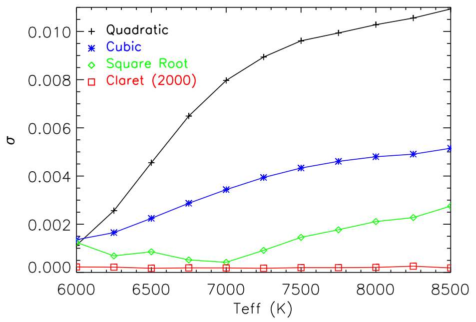

Fig. 1. σ as a function of $T_{\rm eff}$ for four limb-darkening laws ($\log g$ = 4.0, u band, CGM models).

position, a microturbulent velocity of 2 km/s, effective temperatures between 6000 K and 8500 K and $\log g$ between 2.5 and 4.5. Two turbulent convection approaches have been used: the one of Canuto et al. (1996) (CGM) and the classical mixing length prescription (MLT) with α = 0.5 and 1.25. The limb-darkening laws are as in B03; the law proposed by Claret (2000) is also investigated.

2.1. Limb-darkening coefficients for the Strömgren photometric system

For the u and y bands and for CGM models, Claret's law is found to be the best law, i.e. the one which gives the smallest σ (see Eq. 6 in B03) (see Fig. 1 as an ex.), same for the v and b bands except for a few models around 7250 K. For any band, the best law yields a σ smaller than 0.0009 compared to 0.004 found in B03 using simpler limb-darkening laws.

For any band with the adopted best law and for CGM models, the flux computed with the limb-darkening laws fits the ATLAS9 flux to better than 0.11 %, compared to 0.45 % in B03, and the intensity variation over the disk computed from the limb darkening laws to better than 0.5 %, as in B03.

The effect of the convection treatment in the model atmosphere on the choice of the best law is more important between CGM and MLT α = 1.25 than between CGM and MLT α = 0.5 as already mentioned in B03. The σ difference ($\Delta\sigma$) is between 0.3 % and 45 % for CGM models vs MLT α = 0.5 models and between 0.7 % and 177 % for CGM models vs MLT α = 1.25 models.

2.2. Limb-darkening coefficients for the Geneva photometric system

For the U, $V1$, V and G bands and for CGM models, Claret's law is found to be the best law, same for the $B1$, B and $B2$ bands except for a few models around 7500 K. For any band, the best law yields a σ smaller than 0.0003.

For any band with the adopted best law and for CGM models, the flux computed with the limb-darkening laws fits the ATLAS9 flux to better than 0.1% and the intensity variation over the disk computed from the limb darkening laws to better than 0.6 %.

Again, the effect of the convection treatment in the model atmosphere on the choice of the best law is more important between CGM and MLT α = 1.25 than between CGM and MLT α = 0.5 ($\Delta\sigma$ = 5-126 % for CGM models vs MLT α = 0.5 models, $\Delta\sigma$ = 0.2-397 % for CGM models vs MLT α = 1.25 models).

3. Conclusions and future plans

For almost all the models considered in this work, we found that the intensity variations over the stellar surface are better recovered with a multi-parametric non-linear law than with simpler laws, independently of the convection prescription used. The effect of these new LDC on the multicolor photometry method for mode identification is a work in progress.

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