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Application of time-dependent convection models to the photometric mode identification in δ Scuti stars

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Abstract. We apply the Time-Dependent Convection (TDC) treatment of Gabriel (1996) and Grigahcène (2005) to the mode identification and seismic study of δ Sct stars. We compare the non-adiabatic phase-lags obtained with TDC and Frozen Convection (FC) treatments and show that they are very different at the red side of the instability strip. Finally, we compare the phase differences between light and velocity curves observed for the star 1 Mon with the theoretical predictions of TDC and FC models. The much better agreement found with the TDC models enables us to identify the modes of this star with a higher degree of confidency.

Key words. Stars: convection – Stars: oscillations – Stars: interiors – Stars: variables: δ Sct

1. Introduction

A precise determination of the normalized amplitude (f_T) and phase (ψ_T) of effective temperature variation is required for photometric mode identification. As shown by Dupret et al. (2005), the theoretical predictions for these non-adiabatic observables obtained with TDC and FC models are very different for δ Sct stars at the red side of the instability strip. This is illustrated in Fig. 2, where we give the values of ψ_T obtained with TDC and FC models with different α, as a function of the effective temperature, for the fundamental radial mode. We see that the differences are the largest for cold models. As we show in the next section, observations enable us to discriminate between these different theoretical results.

2. Application to 1 Monocerotis

1 Mon is a δ Sct star with 3 clearly observed frequencies: f_1 = 7.346146 c/d, f_2 = 7.475268 c/d and f_3 = 7.217139 c/d. We use here the simultaneous observations of Balona et al. (2001) in Strömgren *uvby* and Cousins *I* photometry and in spectroscopy. From these observations, the phase difference between the photometric magnitude variation in the different

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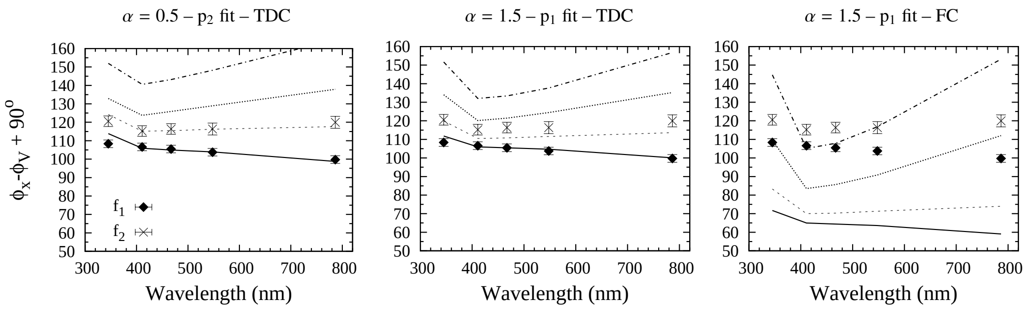

Fig. 2. $\phi_{u,v,b,y,I} - \phi_{V_r} + 90°$, for different models of 1 Mon. The solid, dashed, dotted and dot-dashed lines are the theoretical predictions for ℓ = 0, 1, 2 and 3 respectively. The error bars represent the observations for f_1 and f_2.

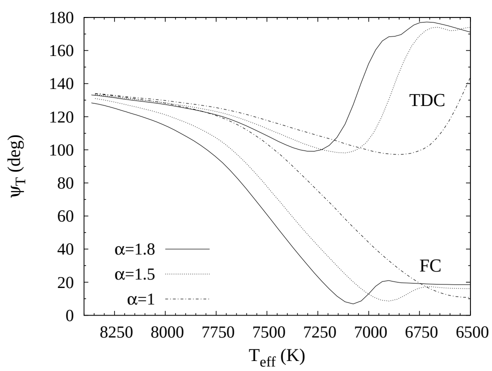

Fig. 1. Evolution of the phase-lag ψ_T as a function of $T_{\rm eff}$, for the fundamental radial mode, obtained with TDC and FC non-adiabatic models with M = 1.8 $M_\odot$ and different α.

passbands and the radial displacement can be determined. The comparison with our theoretical results is shown in Fig. 2 (components f_1 and f_2). The results of left and middle panels are with TDC treatment and the right panel is with FC treatment. The model of left panel is with α = 0.5 and it fits f_1 as the first overtone; the models of middle and right panels are with α = 1.5 and fit f_1 as the fundamental radial mode. We note in Fig. 2 that the discrimination between different ℓ obtained with the spectro-photometric phase-lags is much better than when photometric magnitude variations are only available; this allows a much more secure identification of the modes in the present case. f_1 is clearly identified as a radial mode and f_2 is an ℓ = 1 mode. The current observations do not enable us to know if f_1 is p_1 or p_2. The FC phases completely disagree with the observations.

3. Conclusions

As we have shown here for 1 Mon and in Dupret et al. (2005) for other δ Sct stars, TDC non-adiabatic predictions for the amplitude ratios and phase differences agree much better with observations than the FC ones for cold δ Sct stars. Hence, we stress that TDC models are required for a correct mode identification in these stars.

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