Non-adiabatic study of the *Kepler* subgiant KIC 6442183

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Abstract. Thanks to the precision of *Kepler* observations, [3] were able to measure the linewidth and amplitude of individual modes (including mixed modes) in several subgiant power spectra. We perform a forward modelling of a Kepler subgiant based on surface properties and observed frequencies. Non-adiabatic computations including a time-dependent treatment of convection give the lifetimes of radial and non-radial modes. Next, combining the lifetimes and inertias with a stochastic excitation model gives the amplitudes of the modes. We can now directly compare theoretical and observed linewidths and amplitudes of mixed-modes to obtain new constraints on our theoretical models.

Equilibrium model: We used the frequencies obtained by [3] (obtained from Quarters 5 to 7 of Kepler data) as well as the spectroscopic constraint from [8] to search the structure model of KIC 6442183. The models are computed with the CESTAM evolutionary code [7] using a Levenberg-Marquardt algoritm (OSM) to search for the model parameters that reproduce the spectroscopic and seismic constraints. We fit the spectroscopic constraints and low frequencies modes. The final model is the one for which the non-adiabatic frequencies are the closest to the observed ones. The non-adiabatic calculations allow to partially correct the surface effects at high frequency (see Fig **??**).

Table 1: Global parameters

	Observations	Theoretical model
Mass ($M_\odot$)		1.02
Radius ($R_\odot$)		1.65
T_{eff} (K)	5738 ± 62	5624
$\log g$	4.14 ± 0.10	4.01
$[Fe/H]$	−0.120 ± 0.050	-0.120
$\Delta\nu$ (μHz)	65.07 ± 0.09	65.03
ν_{max} (μHz)	1160 ± 4	

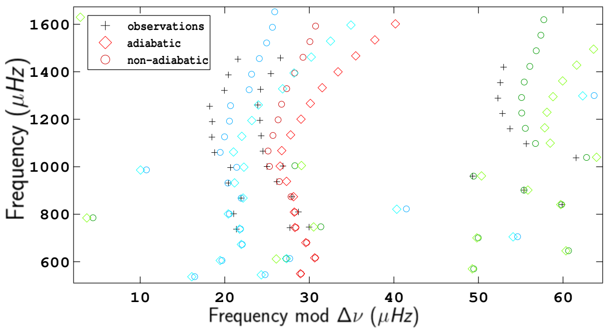

Fig. 1: Left: Global parameters of the star and of the best fit model. **Right:** Echelle diagram of the observed frequencies (black crosses) and of the theoretical adiabatic (diamonds) and non-adiabatic (circles) frequencies

Linewidths and amplitude ratios Theoretical lifetimes strongly depend on the time-dependent treatment of the convection (TDC [5,4]). The free parameter β in this treatment is adjusted following

[2] to reproduce a plateau of the damping rates (or linewidths) at ν_{max}. Theoretical linewidths (left part of Fig 2) globaly reproduce the observed ones, including dipole mixed modes. Amplitudes ratios are independent of the radial velocity to bolometric amplitude conversion and of the instrumental response. They are given by $V^2 = P_R/2\eta MI$ where η is the damping rate of the mode, I its inertia, M the mass of the star and P_R is the reynolds stress contribution given by the stochastic excitation code [9]. The theoretical amplitudes ratios for p-dominated modes mainly depends on the visibilities of the modes (we use the values from [1]) and the error bars are too large to provide additional constraints on the models that could comes from the ratios with g-dominated mixed-modes (see Fig. 2 right panel)

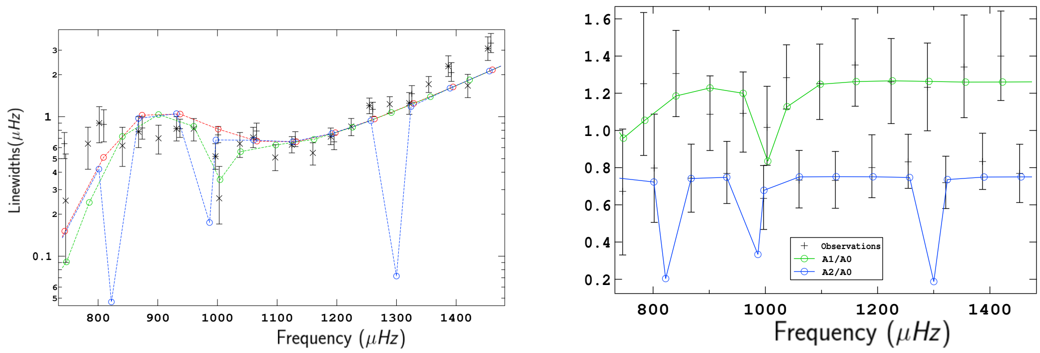

Fig. 2: Left: Observed linewidhts (in black) with our theoretical predictions for l=0,1,2 modes. **Right:** Observed amplitudes ratios (in black) with our theoretical predictions for l=1,2 modes.

Conclusion In the search of the equilibrium model, the use of non-adiabatic frequencies, instead of adiabatic ones, allows us to strongly improve the agreement between observed and theoretical frequencies in the high frequency range [6]. The remaining discrepancies may comes from missing physics in the structure model such as the turbulent pressure ... We find theoretical amplitude ratios within the error bars of the observed ones. Longer duration of observations will certainly help to obtain more constraints on the models and on our TDC treatment. We find three $\ell = 2$ mixed-modes which are not present in [3] (based on 9 months of observations). We predict that they should become detectable with the full length of *Kepler* observations. This work is a first step to improve our modelling of the convection-oscillation interactionand we plan to extend such work to other observed evolved stars.

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