New models for the CoRoT primary target HD 52265, including core overshooting.

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HD 52265 is the only exoplanet host star to be observed as a main target of the seismology programme of the CoRoT mission. In Soriano et al. (2007), we computed models and analysed their oscillation frequencies, as a preliminary work. Here we present new stellar models, computed with overshooting at the edge of the convective core. The influence of this overshooting on the frequencies of HD 52265, and more specifically on the small separations, is small, except for models lying at the end of the main sequence. There, contrary to the predictions of the asymptotic theory, the small separations can become negative in the observed range, and the frequency where this happens is related to the extension of the central mixed zone. All these models are ready for comparison with the CoRoT observations.

Stellar Parameters

HD 52265 is a G0-V type star with a Jupiter-mass planet. Its visual magnitude is V=6.301 mag, and its parallax is π=34.54 ± 0.40 mas. We deduce for HD 52265 a luminosity of: $\log(L/L_\odot)$=0.31 ± 0.03.

Five groups of observers have derived the external parameters of this star (effective temperature, surface gravity and metallicity).

Table 1. Effective temperatures, gravities, and metal abundances observed for HD 52265. [Fe/H] ratios are given in dex.

$T_{\rm eff}$ (K)	log g	[Fe/H]	Reference
6162 ± 22	4.29 ± 0.04	0.27 ± 0.02	GLTR01[a]
6103 ± 52	4.28 ± 0.12	0.23 ± 0.05	SIM04[b]
6076 ± 44	4.26 ± 0.06	0.19 ± 0.03	FV05[c]
6069 ± 15	4.12 ± 0.03	0.19 ± 0.03	TOSKS05[d]
6179 ± 18	4.36 ± 0.03	0.24 ± 0.02	GM06[e]

References: [a] Gonzalez et al. (2001); [b] Santos et al. (2004); [c] Fischer & Valenti (2005); [d] Takeda et al. (2005); [e] Gillon & Magain (2006).

Models

We computed evolutionary tracks, using the TGEC Code (see Hui Bon Hoa 2008) for overmetallic models, using three values of metallicity: [Fe/H]=0.19, 0.23 and 0.27 (see for examples Fig. 1 and 2). We added overshooting at the edge of the stellar core. In the code, overshooting is described as an extension of the convective core by a length α_{ov} H_p, where α_{ov} is the overshooting parameter and H_p the pressure height scale. In our computations, we fixed the overshoot parameter α_{ov} to 0.20.

We chose models with masses and ages close to the ones of the models analysed in Soriano et al. (2007). We computed their adiabatic oscillation frequencies with the PULSE code (Brassard & Charpinet 2008).

We have then computed the small separations and plotted the echelle diagram for each model and we have analysed the influence of overshooting on the frequencies.

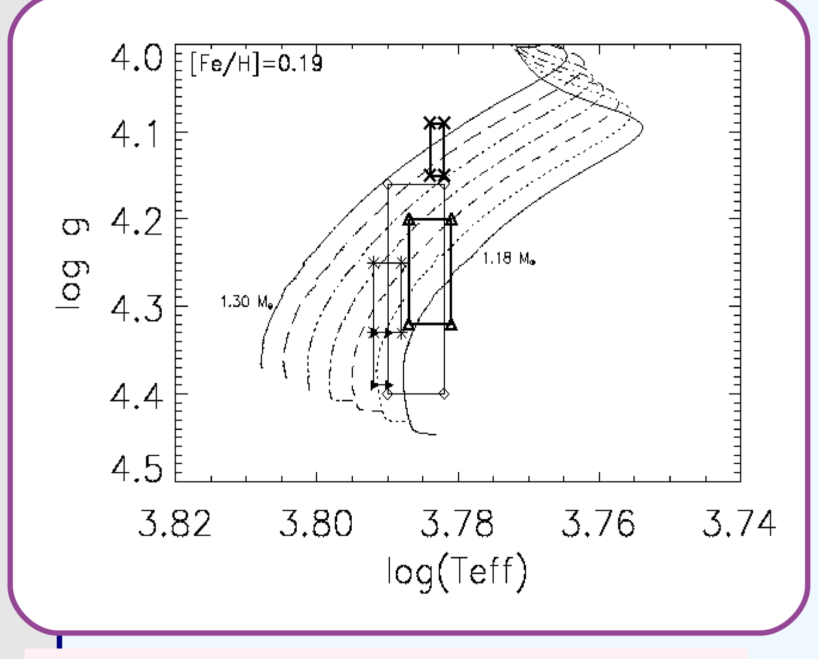

FIG. 1: Evolutionary tracks for overmetallic models with [Fe/H]=0.19 and overshooting. The error boxes shown are from: Gonzalez et al. 2001 (asterisks), Santos et al. 2004 (diamonds), Gillon & Magain 2006 (black triangles), Fischer & Valenti 2005 (triangles), and Takeda et al. 2005 (crosses).

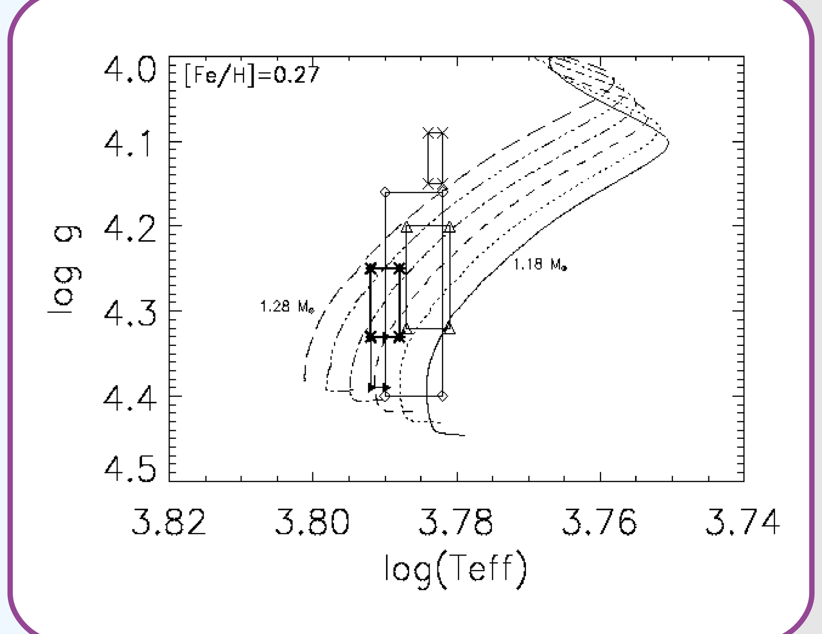

FIG. 2: Evolutionary tracks for overmetallic models with [Fe/H]=0.27 and overshooting.

Seismic Analysis

When overshooting is added at the edge of the core, the evolutionary time scales increase. The development of the convective core is increased during a longer main sequence phase. We chose, for our seismic analysis, models in agreement with the external parameters of HD 52265, i.e. models lying inside the corresponding error boxes. They all correspond to main sequence stars. The radius of their central mixed zone is extended in the case of models with overshooting.

We studied the influence of this extended convective zone on the oscillation frequencies. We show here two examples.

On Fig. 3, we show the example of models of 1.22 $M_\odot$, 1.544 Gyr, [Fe/H]=0.27, with and without overshooting. We can see that we obtain the same value of the large separation and the same echelle diagram in the two cases. There is no clear and visible influence of overshooting on the oscillation frequencies. These models are young, lying at the beginning of the main sequence. Their central helium abundance is low (Yc=0.50 for both models). When overshooting is added, the radius of the convective core is increased, but there is not enough helium in the core to create a discontinuity in the sound speed profile and induce a change in the small separations.

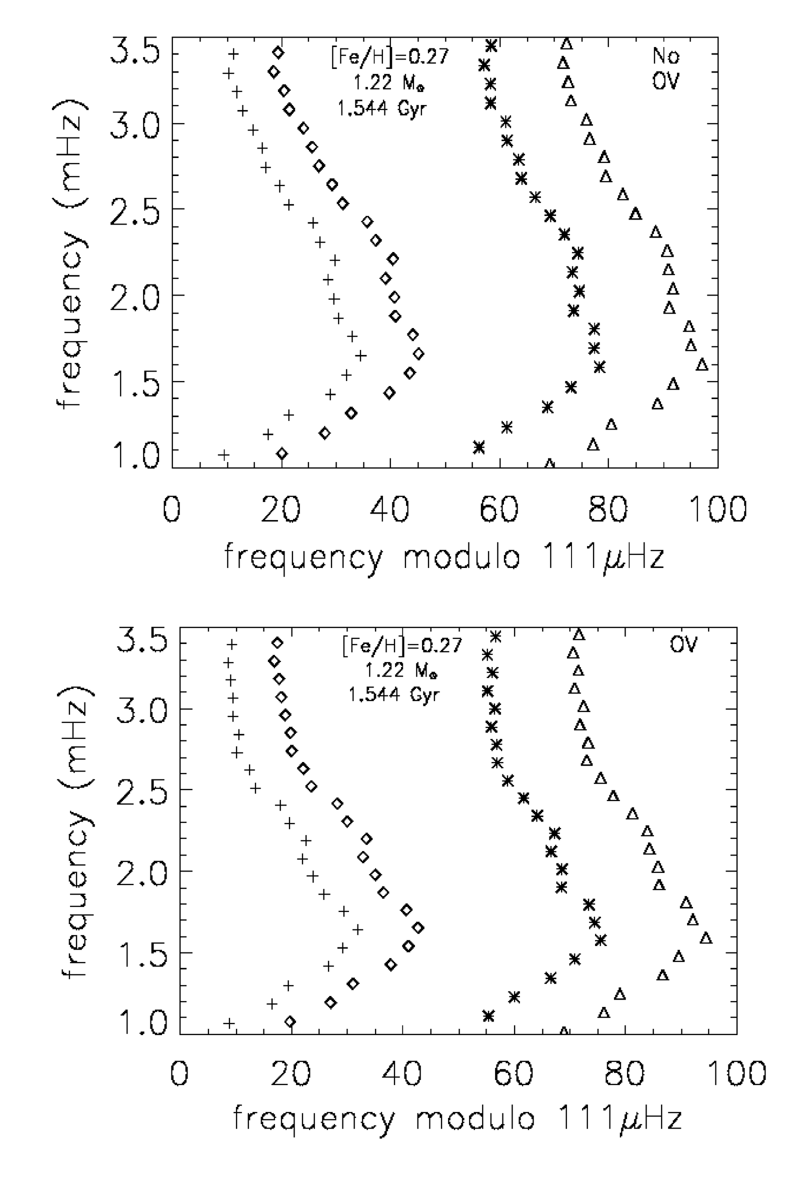

FIG. 3: Echelle diagrams for models of 1.22 $M_\odot$, 1.544 Gyr, [Fe/H]=0.27, without (upper panel) and with (lower panel) overshooting.

On Fig. 4, we show the case of models with [Fe/H]=0.19, lying in the Takeda et al. (2005) error box. In this case, the models correspond to more evolved stars. The model without overshooting has a central helium abundance Yc=0.88, while the one with overshooting has Yc=0.73.

As already described in Soriano et al. (2007) and Soriano & Vauclair (2008), the small separations between l=0 and l=2 become negative at the frequency for which the l=2 waves reach the helium core. We can see that this happens at a lower frequency when overshooting is added, as the central mixed zone is larger.

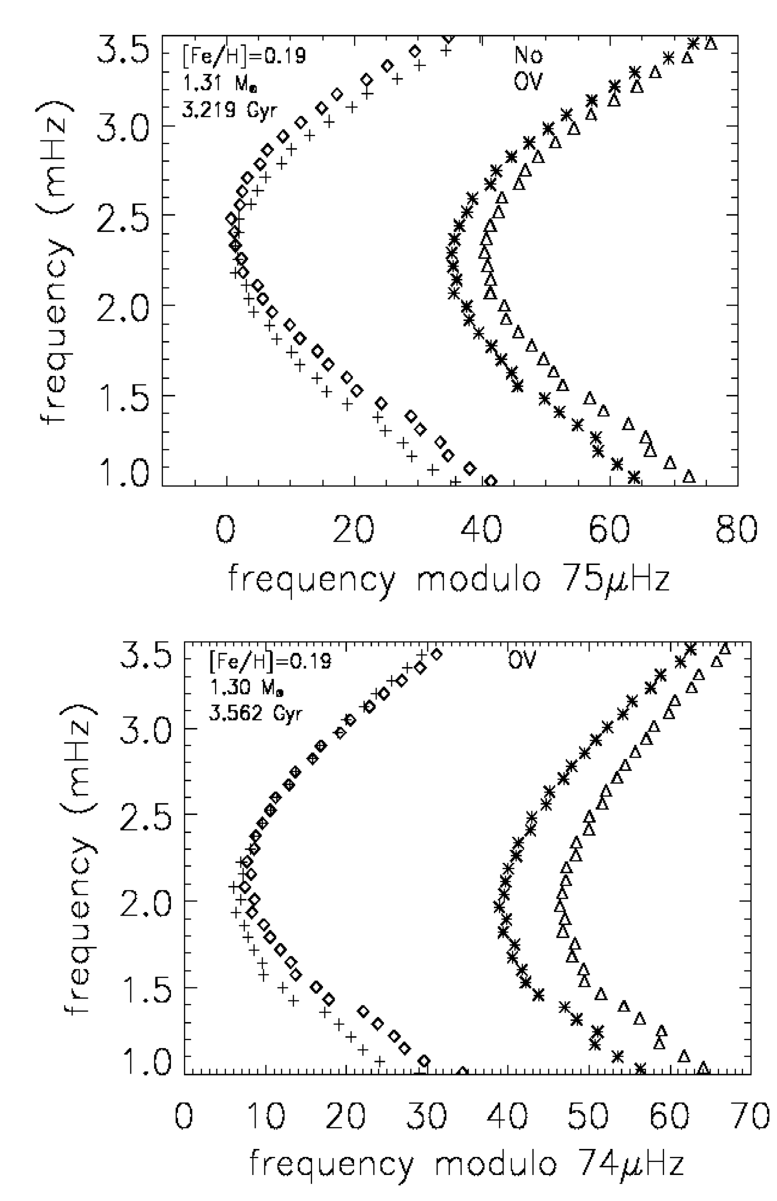

FIG. 4: Echelle diagrams for: a model of 1.31 $M_\odot$, 3.219 Gyr, [Fe/H]=0.19, without overshooting (upper panel), and a model of 1.30 $M_\odot$, 3.562 Gyr, [Fe/H]=0.19, with overshooting (lower panel).

Conclusion

We have computed many models which could account for the spectroscopic parameters of HD 52265, with and without overshooting (see Soriano et al. 2007).

As soon as the data are ready, we will be able to analyse this star. As shown for the cases of other seismically observed main sequence stars : iota Hor (Vauclair et al. 2008) and mu Arae (Soriano & Vauclair, in preparation), we expect to be able to obtain precise values of age, mass and radius of the star, as well as metallicity and primordial helium value, even if other details of the stellar structure cannot be completely disentangled.

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