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Asteroseismic analysis of the CoRoT target HD 169392

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Abstract. The satellite CoRoT (Convection, Rotation, and planetary Transits) has provided high-quality data for almost six years. We show here the asteroseismic analysis and modeling of HD169392A, which belongs to a binary system weakly gravitationally bound as the distance between the two components is of ~ 4250 AU. The main component, HD169392A, is a G0IV star with a magnitude of 7.50 while the second component is a G0V-G2IV star with a magnitude of 8.98. This analysis focuses on the main component, as the secondary one is too faint to measure any seismic parameters. A complete modeling has been possible thanks to the complementary spectroscopic observations from HARPS, providing $T_{\text{eff}}=5985\pm 60\text{K}$, $\log g=3.96\pm 0.07$, and $[\text{Fe}/\text{H}]=-0.04\pm 0.10$.

1. Introduction

Stellar physics are undergoing a tremendous revolution thanks to the large amount of data obtained using photometry, spectroscopy, and interferometry. One major breakthrough the last few years concerned asteroseismology thanks to the exquisite data provided by space-based missions such as CoRoT (Convection, Rotation, and planetary Transits Baglin et al. 2006) and *Kepler* (Borucki et al. 2010). With asteroseismology we can probe the internal structure of the stars (Bedding et al. 2011; Mathur et al. 2012) as well as their dynamics (Beck et al. 2012; Deheuvels et al. 2012). These missions also showed how the search for exo-planet transits and asteroseismology are tightly linked (e.g. Howell et al. 2012). It is undeniable that radius, mass, and age are obtained more accurately with seismic analysis than with classical methods (e.g. Doğan et al. 2013; Metcalfe et al. 2012), thus providing a better estimate of the radii of the planet and the age of planetary systems in the case of planet host stars.

We present here the analysis a solar-like star, HD 169392A observed by CoRoT during the third long run in the central direction of the galaxy (LRc03). We obtained continuous observations for 91.2 days. The time series utilised in this work were prepared by the CoRoT Data Center (CDC) (Samadi et al. 2007). By combining the asteroseismic analysis with spectroscopic observations, we derive the stellar parameters of the stars.

2. Asteroseismic analysis

The data were obtained with a regular cadence of 32 s in the heliocentric frame. The time series is shown in Figure 1 of Mathur et al. (2013) where we can see two jumps at 40.3 and 80.05 days. These jumps are probably of instrumental origin.

We applied the inpainting algorithm (e.g. Sato et al. 2010) to replace the perturbed data due to the South Atlantic Anomaly and remove the peaks corresponding to the daily harmonics. Three components of the background were fitted, including different scales of granulation, with a maximum likelihood estimator (e.g. Mathur et al. 2011).

2.1. Acoustic-mode fitting

Nine teams estimated the mode parameters of HD 169392A using Maximum Likelihood Estimation (MLE), maximum a priori (MAP), and Markov Chain Monte Carlo (MCMC). Minimal and maximal lists of frequencies were built based on the Peirce criterion (Peirce 1852). The results of the fitting analysis can be found in Mathur et al. (2013). The $l=3$ modes were fitted and belong to the maximal list. We notice the presence of an avoided crossing suggesting the presence of a mixed mode (e.g. Osaki 1975). By applying the formalism developed by Mosser et al. (2012), we find a gravity period spacing $\Delta\Pi=476.9\pm4.3$ s. We report 2 mixed modes at 816 and 1336 μ Hz. The first one is surrounded by the orbital harmonics of CoRoT while the second one has a very weak signal so it was not fitted.

No signature of surface rotation was found in the light curve. We performed multiple fits for a fixed rotational splitting and a range of fixed angles. Two maxima of almost equally high probability were obtained in the joint-posterior probability density function. So two different values for the joint-parameters are possible: an inclination angle between 20 and 40° with a rotational splittings of 0.4-1.0 μ Hz or between 55 and 86° for a rotational splittings of 0.2-0.5 μ Hz.

2.2. Modeling

Using the spectroscopic constraints and the asteroseismic parameters, we modeled HD169392A with the Asteroseismic Modeling Portal (AMP, Metcalfe et al. 2009), the infrared flux method (IRFM, Casagrande et al. 2010), and the IRFM combined with grid-based method (Silva Aguirre et al. 2012). The results agree within uncertainties. For the AMP model, we computed the frequency ratios, r_{01} and r_{10} as in Roxburgh & Vorontsov (2003). They are sensitive to the core structure of the star. The comparison of the frequency ratios from the observations and the models (Figure 1) shows a good agreement (χ^2 of 8 and 4) suggesting that the models reproduce well the surface and the interior of the star.

3. Conclusions

We extracted the mode parameters for $l=0, 1, 2$, and 3 for HD169392A. The signal-to-noise ratio of the second component was too weak to study the oscillations. The analysis of splittings and inclination angle gives two possible solutions: one with splitting and inclination angle of 0.4-1.0 μ Hz and 20-40°, the other with 0.2-0.5 μ Hz and 55-86°. The Asteroseismic Modeling Portal (AMP) gives a mass of $1.15\pm0.01M_{\odot}$, a radius of $1.88\pm0.02R_{\odot}$, and an age of 4.33 ± 0.12 Gyr, for a given physics (Metcalfe et al.

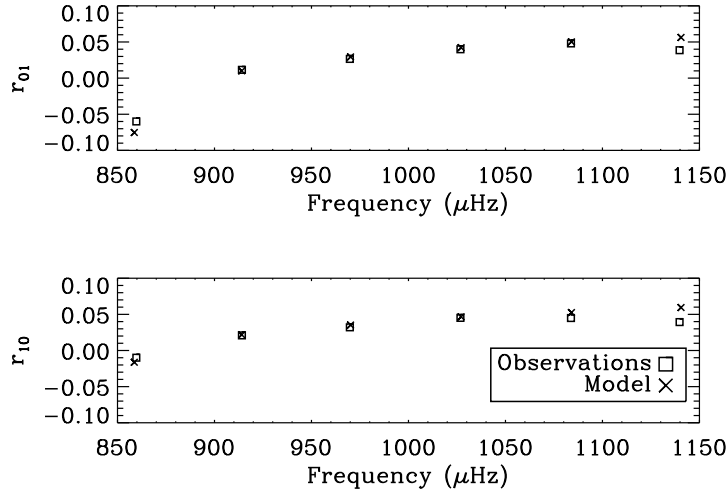


Figure 1. Frequency ratios of HD169392A as defined in Roxburgh & Vorontsov (2003) in the range 850 to 1150 μ Hz. The square symbols represent the observations while the crosses represent the best-fit model from AMP.

2012). The error bars are the internal uncertainties. These results agree with results obtained from other modeling methods. We conclude that this star is a subgiant that has exhausted its central hydrogen and has no convection core. The study of the frequency ratios, r_{01} and r_{10} , shows good agreement between the best-fit model from AMP and the observations, which implies that the properties of the core are well represented by the model.

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