Effects of the HeII ionization zones on oscillation frequencies
Applications to Kepler and CoRoT stars

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ABSTRACT. Solar-like oscillation frequencies of 93 target stars of *Kepler* and *CoRoT* are analyzed. In the present study, we present results for two of them. Recently, two new reference frequencies ν_{min1} and ν_{min2} are found in the spacing of solar-like oscillation frequencies of stellar interior models. In order to fit model frequencies to observational frequencies, we change model mass and hydrogen abundance. We also try to obtain similar patterns around min1 and min2 for model and observational frequencies.

INTRODUCTION. There are several paper about finding fundamental parameters of solar-like stars with asteroseismology in the literature. In this work, we analyze two *Kepler* target stars, namely, KIC 11244118 and KIC 8524425. The models of these stars are constructed with using the MESA evolution code (Paxton et al. 2011; 2013). For asteroseismic investigation, we use method which is explained in detail in Yıldız et al. (2014a; 2015). There are several minima in their $\Delta\nu$ versus ν graph. We check if observational and theoretical results are in agreement in such a graph.

Properties of the MESA code

In this study, these models are constructed by using Modules for Experiments in Stellar Astrophysics (MESA) evolution code (Paxton et al. 2011; 2013). Nuclear reaction rates are taken from Angulo et al. (1999) and Caughlan & Fowler (1988). Convection is treated with standard mixing-length theory (Böhm-Vitense 1958). MESA offers the opacity tables of Iglesias & Rogers (1993; 1996) and includes their OPAL opacity tables with fixed metal distributions as the default option. We selected simple photosphere for atmospheric boundary condition. We do not use microscopic diffusion in the models. The model frequencies are computed using ADIPLS (Christensen-Dalsgaard 2008).

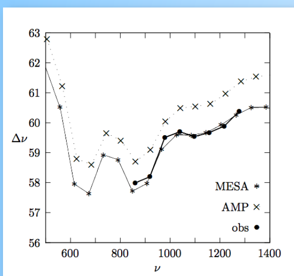

Figure 1. $\Delta\nu$ versus ν graph for model (MESA and AMP) and observational frequencies of KIC 8524425.

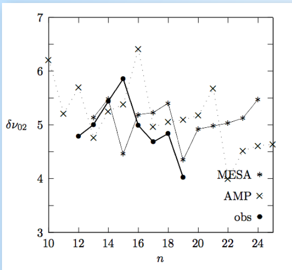

Figure 2. Small separation between the oscillation frequencies with respect to *n* for KIC 8524425.

KIC 8524425 (Sub-giant Star)

KIC 8524425 (TYC 3142-1229-1) is an active star and visual magnitude is $9^m.191$ (SIMBAD). Atmospheric properties of KIC 8524425 taken from Metcalfe et al. (2010), are listed in Table 1.

In this study, we find heavy element abundance from [O/H] in Yıldız et al. (2014b). We construct MESA models with Z=0.0175. In order to fit model frequencies to observational frequencies, we change model mass and hydrogen abundance. Our model results are listed in Table 2. Large separations of MESA and AMP models with observational frequencies are plotted in Fig. 1. MESA model frequencies are in better agreement with observational frequencies than AMP model frequencies. However, we see only part of min1 for observational frequencies. We determined age of this star as 8.5 Gyr. $\delta\nu_{02}$ – n relation is plotted in Fig. 2.

Table 1. Observation properties of KIC 8524425 and KIC 11244118.

KIC	$T_{\rm eff}$ (K)	[Fe/H] (dex)	log g (dex)	$\Delta\nu$ (μHz)	$\delta\nu_{02}$ (μHz	$\nu_{\rm max}$ μHz)	$\nu_{\rm min0}$ (μHz)	$\nu_{\rm min1}$ (μHz)	$\nu_{\rm min2}$ (μHz)
8524425	5634±84	0.14±0.09	—	59.700	4.954	1065.224	1093.430	880.480	667.310
11244118	5735 ±60	0.35 ± 0.09	4.230 ± 0.080	71.400	4.748	1324.855	1518.580	1163.690	880.730

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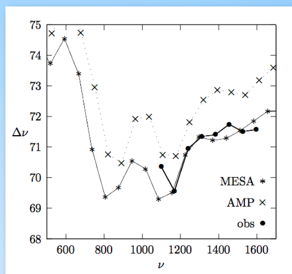

Figure 3. $\Delta\nu$ versus ν graph for model (MESA and AMP) and observational frequencies of KIC 11244118.

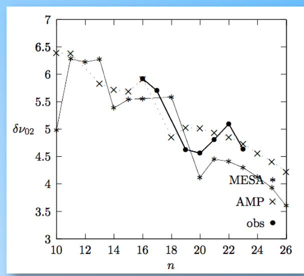

Figure 4. Small separation between the oscillation frequencies with respect to *n* for KIC 11244118.

KIC 11244118 (Sub-giant Star)

KIC 11244118 was observed short cadence (58.85 s, Gilliland et al. 2010) by *Kepler*. Observational atmospheric parameters are taken from Bruntt et al. (2012) and listed in Table 1.

Models are constructed by using MESA. We change model mass and hydrogen abundance to fit model frequencies to observational frequencies. MESA model are in agreement with atmospheric and seismic observational parameters. In Table 2, MESA and AMP model (taken from Metcalfe et al. 2014) results are listed. $\Delta\nu$ versus ν graph for model (MESA and AMP) and observational frequencies of KIC 11244118 is plotted in Fig. 3. Small separation between the oscillation frequencies (observation, MESA and AMP models) with respect to n for KIC 11244118 is plotted in Fig 4.

CONCLUSION. In the present study, we analyse two Kepler target stars (KIC 8524425 and KIC 11244118). We construct interior models for these stars with using the MESA evolution code. We compare our best model results with AMP models. Fundamental parameters and seismic properties of KIC 8524425 and KIC 11244118 are in agreement with observed values. For KIC 8524425 and KIC 11244118, patterns of model frequencies are very similar to the observed patterns in $\Delta\nu$-ν graphs (see in Fig. 1 and 3). Also, we have matched small separations of frequencies for KIC 8524425 and KIC 11244118 (see Fig. 2 and 4). Input parameters of MESA models (M, Z, X, α) are different from AMP, but model ages are found very similar for KIC 8524425. The model ages for KIC 11244118, however, are significantly different, approximately 2.7 Gyr. This discrepancy may arise from extremely low hydrogen abundance of the AMP model.

Table 2. Fundametal parameters of KIC 8524425 and KIC 11244118 are constructed by using MESA. Also AMP models are listed.

	M ($M_\odot$)	X	Z	α	t (Gyr)	T_{eff} (K)	L ($L_\odot$)	R ($R_\odot$)	*logg*	$\delta\nu_{02}$ (μHz)	$\Delta\nu$ (μHz)	ν_{max} (μHz)	$\nu_{\rm min0}$ (μHz)	$\nu_{\rm min1}$ (μHz)	$\nu_{\rm min2}$ (μHz)
KIC 8524425															
AMP	1.10	0.72232	0.01968	1.820	8.260	5501	2.634	1.790	3.973	5.167	61.746	1189.66	1161.24	881.76	645.08
MESA	1.07	0.69850	0.17500	2.000	8.512	5614	2.867	1.792	3.961	5.066	59.981	1030.78	1093.43	880.48	677.31
KIC 11244118															
AMP	1.10	0.66280	0.02716	2.160	6.430	5838	2.632	1.589	4.077	4.391	73.773	1321.79	1540.14	1141.03	854.16
MESA	1.09	0.71100	0.02000	2.100	9.124	5727	2.470	1.598	4.068	5.576	71.858	1306.78	1405.78	1117.22	814.48

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