Radial and Nonradial Pulsations as Probes of Stellar Physics
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Asteroseismology of Delta Scuti Stars – A Parameter Study

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Abstract. We assess the potential of asteroseismology for determining the fundamental properties of individual δ Scuti stars. We computed a grid of evolution and adiabatic pulsation models to study systematic changes in $\ell = 0, 1, 2$, and 3 modes as functions of fundamental stellar properties. Mass has the strongest effect on evolution and on pulsation, followed by the metal abundance. Changes to the helium content have very little effect on the frequencies until near the end of the main sequence. Changes to each of the four parameters change the p-mode frequencies more than they do the g- and mixed-mode frequencies, suggesting that these parameters have a greater effect on the outer layers of the star. We also present pulsation models of FG Virginis, outlining a possible method of locating favorable models in the stellar parameter space based upon a definitive identification of only two modes. We plot evolution models on the (period-period ratio) and (temperature-period ratio) planes to select candidate models, and modify the core overshooting parameter to fit the observed star.

1. The effect of fundamental parameters on pulsation frequencies

We tested the effects of changing the mass, helium and metal abundances, and convective core overshooting parameter on a grid of δ Scuti evolution models, in the hope that we might quantify how individual parameters affect the pulsation behavior.

Fig. 1 shows the evolution of the $\ell = 0, 2$ frequencies as a function of time for stars with two different masses. Changing the mass has the most effect on the frequencies, with shifts of several microhertz at a given ℓ, n for both p-type and g-type modes. The large separations $\delta\nu = \nu_n - \nu_{n-1}$ are also different, which may serve as a diagnostic tool when individual mode identifications cannot be made, but an average frequency separation can. Changes to the metal abundance and core overshooting parameter also show up in the pulsation frequencies, but changes to the helium content yield little difference in the observed frequencies until near the end of the main sequence. Changes in the core overshooting parameter manifest themselves in the frequencies over time, since models with and without overshoot are essentially identical at the ZAMS.

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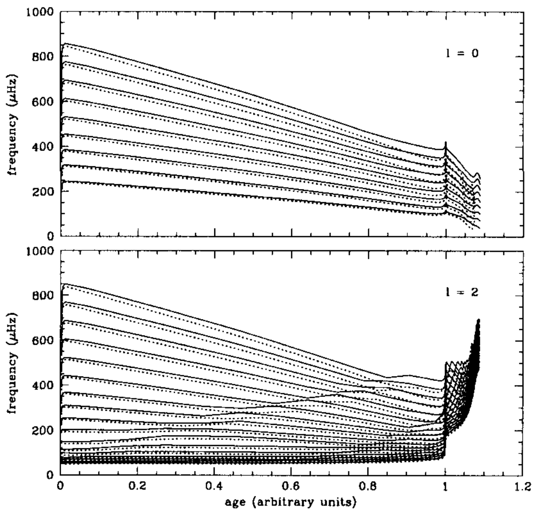

Figure 1. Evolution of model frequencies with age for two models of different masses. Solid lines: M = 1.8 $M_\odot$; dashed lines: M = $2.0_\odot$. Ages are normalized to the peak frequency near the main-sequence turn-off. Figure after Christensen-Dalsgaard (2000).

2. FG Virginis models and model constraints

We generated a small set of models consistent with the observed properties of FG Virginis. Our goal is not to fit FG Vir itself, but study the behavior of model frequencies to determine whether we can easily constrain the parameter space of models based upon only a small amount of information. We generated Petersen diagrams (evolution of period versus period ratio) for our model grid, but we also plotted the evolution in the *temperature* versus period ratio planes, and used the observed constraints given in Breger et al. (1999). We found that of the four parameters, changes to the mass and chemical abundances produce the same effect – models move toward the desired fit point in one plane, but away from it in the other. Changes to the convective core overshooting parameter improved the fit simultaneously in both planes. This suggests that favorable model candidates may be selected by obtaining a best-fit in mass and abundances, and then using the core overshooting length to tune the model fit. We note that rotation was not included in these calculations, but could be added to the parameter space and tested in a similar way.

References

Breger, M., et al. 1999, A&A, 341, 151

Christensen-Dalsgaard, J. 2000, in ASP Conf. Ser., Vol. 210, Delta Scuti and Related Stars, eds. M. Breger & M. Montgomery, (San Francisco ASP), 187

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