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Suppressing g Modes in Shell Hydrogen-Burning δ Scuti Stars

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For shell hydrogen-burning δ Scuti stars, many more unstable modes are predicted than are observed. For example, for 4 CVn and δ Scuti itself, only 18 and 6 modes are observed, respectively, whereas several hundred $\ell = 0$, 1 and 2 rotationally-split modes are predicted. The predicted modes have a mixed p- and g-mode character, with many g-type nodes present in the H-exhausted core and shell H-burning region, where the Brunt–Väisälä frequency is large.

Here we explore whether the predicted frequency spectrum can be made to agree better with the observed spectrum if the g-mode character of the pulsation modes is partially suppressed. Additional motivation for this approach is provided by the observation by Breger et al. (1999) that 4 modes in 4 CVn identified as $\ell = 1$ have nearly equal frequency spacings of $\sim$14 μHz, reminiscent of consecutive radial orders from a pure p-mode spectrum. We consider 2.1- and 2.3-$M_\odot$ evolutionary models that match the observed $T_{\rm eff}$, L, and $\log g$, plus an identified radial mode frequency of 4 CVn and δ Scuti. For these models, we experimented with setting the Brunt–Väisälä frequency to zero from the model center to the edge of or beyond H-depleted core, so that the g-type portion of the waves becomes evanescent in this region.

We find that the frequency spacing agrees best with observations if the Brunt–Väisälä frequency is set to zero throughout the core and most of the H-burning shell. In this case, the number of predicted modes in the observed frequency range is reduced by a factor of three, but many more modes are still predicted than observed.

More work is necessary to develop some physical justification for the possible suppression of core g-mode propagation. These stars are not predicted to have convective cores or shells which would damp g modes. Nonadiabatic calculations by Lee (1985) and Guzik (reported by Cox 1990) show that, unlike red giants and Cepheids with degenerate cores, the radiative dissipation in evolved δ Scuti stars is insufficient to prevent the formation of standing waves in the core.

References

Breger, M., Handler, G., Garrido, R., et al. 1999, A&A, 349, 225

Cox, A. N. 1990, in Nonlinear Astrophysical Fluid Dynamics, eds. J.R. Buchler & S.T. Gottesman, New York Acad. Sci., pp. 54-72

Lee, U. 1985, PASJ, 37, 279