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Nonlinear Survey of RRd Models

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Abstract. We used our nonlinear hydrodynamical code with turbulent convection to model RR Lyrae stars. In some regime this approach produces double-mode solutions. We investigated series of models with different parameters (metallicity, luminosity, etc.). Our goal was to estimate the width of the double-mode region. The resulting tendencies can be directly compared with observational properties.

The aim of this work was to map the topology of the RRd area in the $T_{\rm eff} - L - Z - \alpha_\nu$ (turbulent eddy viscosity) parameter-space at a given stellar mass. An implicit, 1-D Lagrangian, nonlinear hydrodynamical code (Buchler, Kolláth, & Marom 1997) was used that includes turbulent convection (Yecko, Kolláth, & Buchler 1998). Sequences of models were computed with different parameters covering a reasonable range of observable and numerical parameters ($L = 35-55$ $L_\odot$, $Z = 10^{-4} - 4 \times 10^{-3}$, $\alpha_\nu = 0.2 - 1.8$). Stellar masses (0.77 $M_\odot$) and hydrogen content (X=0.75) were fixed. The following numerical (dimensionless) parameters were used: number of zones: 120, $\alpha_{\rm l} = 0.41$, $\alpha_{\rm c} = 0.75$, $\alpha_{\rm s} = 0.75$, $\alpha_{rmt} = 1.0$, $\alpha_{\rm d} = 4.0$, $\alpha_{\rm p} = \frac{2}{3}$. The calibration of the luminosity–metallicity relation is based on the empirical relation of Jurcsik (1998a) and Table 1 in Dorman's (1992) paper was used for the [Fe/H] - Z conversion for horizontal-branch stars. We list here some apparent *tendencies* from our sequences:

- An increase in *luminosity* yields a narrower double-mode region DMR and shifts it to higher temperatures (Fig. 1). After the vanishing of double-mode pulsation a broad *either-or region* appears.
- Surprisingly the *metallicity* parameter causes only minor differences.
- The shape of the $\alpha_\nu - T_{\rm eff}$ diagram is similar to Fig. 1: an increase in *eddy viscosity* pushes the DMR to higher $T_{\rm eff}$. Another interesting feature is again the apparent either-or region at the blue edge of the DMR.
- In order to compare the *location of the DMR* with observational results, models of lower masses were built and similar surveys of lower masses (Bono, Castellani, & Stellingwerf 1995; Feuchtinger 1998) were taken into account. This comparison revealed that the DMR of 0.65 $M_\odot$ is shifted by 150 – 200 K to the blue. In this way excellent agreement can be seen with the position of observed RRd stars in M3 (Bakos & Jurcsik 2000).

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- Nevertheless, there is still a discrepancy between the empirical and theoretical slopes and orientations of the *blue edge of the fundamental instability strip* in the $L = 35 - 55L_\odot$ interval (Jurcsik, 1998b).

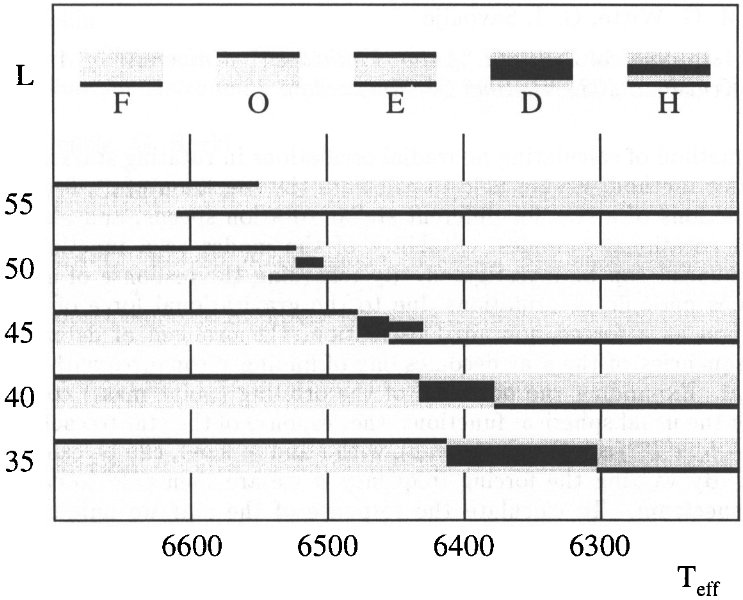

Figure 1. Double-mode (DM) instability region at Z=0.0001, α_ν=1.0. F: fundamental mode only, O: first overtone only, E: either fundamental mode or first overtone, D: DM only, H: either DM or fundamental mode.

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