Mapping Convection using Pulsating White Dwarf Stars

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Parametrization of Convection Zone

As shown by Montgomery (2005), the non-sinusoidal shape of the light curves of pulsating white dwarf stars can be used to constrain models of convection in these objects. In particular, $\tau$, the timescale on which the convection zone responds to a change in input flux at its base, can be parametrized as

$$\tau = \tau_0 \left( \frac{T_{\text{eff}}}{T_{\text{eff}0}} \right)^{-N},$$

where $\tau_0$ and $T_{\text{eff}0}$ are the equilibrium values of $\tau$ and the effective temperature, respectively, $T_{\text{eff}}$ is the instantaneous effective temperature, and $N$ is an exponent which determines how rapidly the depth of the convection zone changes with $T_{\text{eff}}$.

![Figure 1: $\tau_0$ versus $T_{\text{eff}}$ assuming the pure He (no H) $T_{\text{eff}}$ values from Table 1.](image)

Table 1: Derived convective parameters for two DBVs

<table>
<thead>
<tr>
<th>star</th>
<th>$\theta_i$ (deg)</th>
<th>$\tau_0$ (sec)</th>
<th>$N$</th>
<th>$T_{\text{eff}}$ (no H)</th>
<th>$T_{\text{eff}}$ (with H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GD 358</td>
<td>62</td>
<td>450</td>
<td>25</td>
<td>24,900 K</td>
<td>24,700 K</td>
</tr>
<tr>
<td>PG1351+489</td>
<td>58</td>
<td>87</td>
<td>21</td>
<td>26,100 K</td>
<td>22,600 K</td>
</tr>
</tbody>
</table>
Mapping the DBV Instability Strip

We currently have examined two stars in the DBV instability strip: PG 1351+489 and GD 358. In Table 1, we list the convective parameters of the fits to these stars, as well as the derived inclination angles, $\theta_i$. In addition, we list the effective temperatures determined from spectroscopic fits (Beauchamp et al. 1999), both for the case of pure He atmospheres and for the case of H contamination.

In Fig. 1, we show the location and slopes of these stars in the log $\tau_0 - T_{\text{eff}}$ plane, and we show the predictions of the Böhm & Cassinelli (1971) mixing length theory (ML2) for various values of $\alpha$ (dashed curves). ML2/$\alpha = 1.1$ provides a reasonable fit to the $\tau_0$ of these stars. We note that if the effective temperatures assuming H contamination are used, we obtain the nonsensical result that the cooler star has the thinner convection zone (i.e., smaller value of $\tau_0$), something which is not possible based on very general arguments.

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References

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