Comm. in Asteroseismology
Vol. 157, 2008, Wrocław HELAS Workshop 2008
M. Breger, W. Dziembowski, & M. Thompson, eds.

Is HD 163899 really a supergiant star?

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Abstract

According to its spectral type B2 Ib/II (Klare & Neckel 1977; Schmidt & Carruthers 1996), HD163899 is a supergiant star. The star presents p and g-mode pulsations (Saio et al. 2006). In such a post-main sequence (post_MS) star, the helium core is radiative with a very large Brunt-Väisälä frequency which produces a strong damping. The presence of excited g-modes is however possible thanks to an intermediate convective zone (ICZ) which prevents some g-modes from entering the radiative damping core (Saio et al. 2006). We have investigated an alternative solution. We show that MS evolutionary tracks could cross the error box of HD 163899 if a sufficiently large amount of overshooting is taken into account. However, in that case, the spectrum of unstable modes is different from the spectrum of a supergiant star since the Brunt-Väisälä frequency is much smaller.

Individual Objects: HD 163899

HD 163899

HD 163899 is a B supergiant star (B2Ib/II, Klare & Neckel 1977; Schmidt & Carruthers 1996) which has been observed by the MOST satellite (Walker et al. 2003) during 37 days. Saio et al. 2006 reported the detection of 48 frequencies ($\leq$ 2.8 c/d) with amplitudes of the order of the milli-magnitude. The frequency range corresponds to p and g-mode pulsations.

HD 163899 is a supergiant star

The presence of g-mode pulsations in a post-MS star is challenging since those stars present a radiative and contracting core and a low density envelope. The Brunt-Väisälä frequency reaches huge values in the core causing a strong radiative damping. However, an intermediate convective zone (ICZ) located above the core prevents some modes from entering the radiative damping core. In that case the κ-mechanism in the superficial layers is sufficient to excite some g-modes (Saio et al. 2006). Saio et al. (2006) have computed supergiant models in which an ICZ indeed develops in the post-MS phase. They do have excited g-modes and the frequency range corresponds approximately to the observed frequencies.

HD 163899 is a main sequence star with overshooting

MS stars have a convective core surrounded by a radiative envelope: the Brunt-Väisälä frequency is zero in the core and no radiative damping occurs there. The presence of g-modes in such a star is therefore not a problem. Fig. 1 shows evolutionary tracks computed with different overshooting parameters (from 0.2 to 0.5). The black dashed box stands for

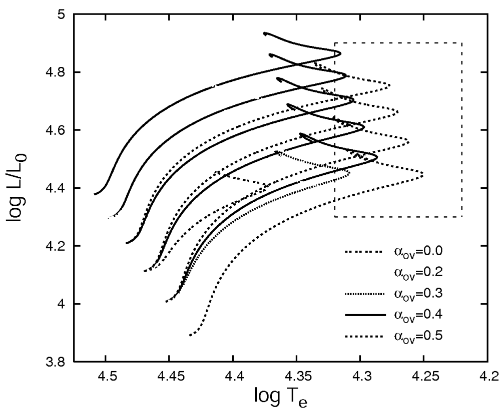

Figure 1: Main sequence evolutionary tracks for masses ranging from $11M_\odot$ to $16M_\odot$ computed with different overshooting parameters ranging from 0.2 to 0.5. The dashed box is the error box of HD 163899. Main sequence evolutionary tracks with at least $\alpha_{ov} = 0.3$ cross this error box.

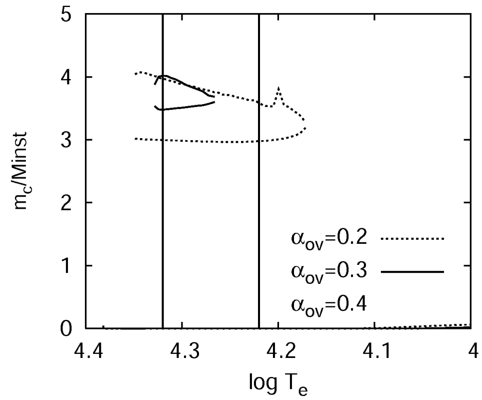

Figure 2: Evolution of the ICZ mass extension during the supergiant phase. The effective temperature decreasing after the MS is shown on x-axis. For a small amount of overshooting 0.2, the ICZ is well develops, it is much smaller for 0.3 and it disappears for 0.4.

the error box of HD 163899 from Saio et al. (2006). We see that when taking sufficiently large overshooting into account, MS evolutionary tracks cross the error box of HD 163899. g-modes can be excited since there is no radiative damping due to the presence of a convective core. However, the frequency range does not represent the observed range as well as in case 1.

HD 163899 is a supergiant star with overshooting

On the post-MS, an ICZ is needed to have excited g-modes. If the overshooting during the MS phase is too large, it can prevent the formation of an ICZ during the post MS and therefore prevent the excitation of the g-modes. The evolution of the convective core and the ICZ in the post MS phase for a sequence of $12M_\odot$ computed with different overshooting parameters is shown on fig. 2. The ICZ is still well developed for $\alpha_{ov} = 0.2$, it is much smaller for 0.3 and it completely disappears for $\alpha_{ov} = 0.4$. In that case, no unstable g-modes should be observed.

Conclusion

We have investigated three possible solutions for the location of HD163899 in the HR diagram coupled with the presence of excited g-modes. First, if HD 163899 is a supergiant star, an ICZ is needed and for models computed without overshooting the theoretical frequency range closely resembles the observed frequency range. Second, if HD 163899 is still a MS star, a rather large amount of overshooting is needed. However in that case, the agreement between the theoretical frequency range and the observed one is not as good as in case 1. Third, if HD 163899 is a supergiant star with a rather large amount of overshooting during the MS phase, no ICZ is formed and the excitation of g-modes is not possible. These results favour case 1; HD 163899 should be a supergiant star.

References

Klare, G. & Neckel, T. 1977, A&AS, 27, 215

Saio, H., Kuschnig, R., Gautschy, A., et al. 2006, ApJ, 650, 1111

Schmidt, E. & Carruthers G., ApJ, 104, 101

Walker, G., Matthews, J., Kuschnig, R., et al. 2003, PASP, 115, 1023