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Asteroseismology and mode driving of the Herbig Ae star HD 104237

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Abstract

Eight pulsation frequencies were detected in the Herbig Ae star HD 104237 during two observational campaigns in 1999 – 2000 (Böhm et al. 2004). Moreover, Böhm et al. (in preparation) detected recently in their data two independent signatures of a signal at 95 hr that corresponds probably to rotational modulation. We present here a seismic study of this Pre-Main Sequence star based on these observations. Different possible interpretations of the pulsation spectrum are considered. The driving of the pulsation modes is not explained by standard models, the observed frequencies being too high for δ Scuti-type pulsations. We consider the effect of He accumulation in its partial ionization zones as a possible explanation for this driving.

Interpretation of the frequencies

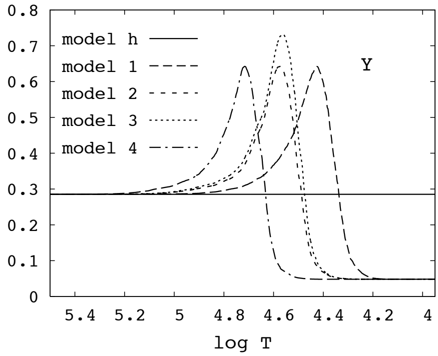
There are different determinations of $T_{\rm eff}$ for HD 104237 (see Dupret et al. 2006). The highest degree of confidence can be given to the value $T_{\rm eff} \simeq 8250 \pm 150$ K determined by Böhm et al. (in preparation) on the basis of the many spectra obtained during the campaign. As there is no mode identification, we must make some guess for the interpretation of the pulsation frequencies.

In a first family of possible solutions, the approximate equidistance found around 2.3 c/d in the observed spectrum is interpreted as the large separation (see Dupret et al. 2006). The problem of this solution is that the required radius is large. Hence, the theoretical luminosity is larger than the observed value (parallax known).

In a second family of possible solutions, a multiplet appears as a possible rotational splitting and two radial modes are fitted. Models near the observed $T_{\rm eff}$ and L are found in this case. However, the predicted frequency splitting for solid rotation (95 hr period) is smaller than observations. If we see really a rotational splitting, this could be an indication of differential rotation.

Mode driving

The driving of the observed pulsation modes of HD 104237 is not explained by standard models. Even if it was inside the classical instability strip (which is not the case with the new determination by Böhm et al.), the frequencies of the predicted unstable modes would be too low compared to observations. We consider here the effects of inhomogeneous He distributions on mode excitation. In HD 104237, a He accumulation could arise in the external layers of the stars, resulting from the combined effects of magnetic field (which might suppress convection), microscopic diffusion and winds. A detailed prescription of these processes is not included in the models presented here: as a first step, we just impose in our models different ad-hoc He accumulation profiles (Fig. 1) parametrized in a similar way as proposed



	Unstable modes	
Model h	All modes are stables	
Model 1	p_7	26.49 c/d
Model 2	p_5 - p_8	20.69 - 29.46 c/d
Model 3	p_5 - p_9	20.68 - 32.53 c/d
Model 4	p_5 - p_6	20.72 - 23.64 c/d
Observations		28.50 - 35.61 c/d

Figure 1: Left: Different He profiles. Right: Ranges of predicted unstable modes as compared with the observed frequency range.

by Balmforth et al. (2001). Our models have the same global parameters: $M = 2.3M_{\odot}$, $\log T_{\rm eff} = 3.915$, $\log(L/L_{\odot}) = 1.55$, $Z = 0.012$.

The different He profiles of Fig. 1 affect significantly the opacity in the He partial ionization zones. This affects in turn significantly the κ-driving of the modes as shown in the right panel. In model 3, the opacity drop at $\log T \simeq 4.6$ is the steepest and as a consequence the largest number of modes are excited, up to frequencies of 32.53 c/d. We do not reach yet the observed upper limit at 35.6 c/d but our results are already encouraging.

References

Balmforth N. J., Cunha M. S., Dolez N., Gough D. O., Vauclair S., 2001, MNRAS, 323, 362

Böhm T., Catala C., Balona L., Carter B., 2004, A&A, 427, 907

Dupret M.-A., Böhm T., Goupil M.-J., Catala C., Grigahcène A., 2006, Comm. Asteroseis., 147, 72