

THE ACOUSTIC CUT-OFF FREQUENCY OF ROAP STARS

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For 5 out of 28 known rapidly oscillating magnetic chemically peculiar (roAp) stars, the largest observed frequency seems to exceed the theoretical acoustic cut-off frequency, which is determined by the outermost stellar regions. We show that a better modelling of the atmosphere reconciles the theory with the observations for at least the roAp star α Cir.

We have compared models and adiabatic frequencies for pulsating Ap stars with $T(\tau)$ laws based on Hopf's purely radiative relation and on Kurucz model atmospheres. For α Cir we find models with Kurucz atmospheres which have indeed a cut-off frequency beyond the largest observed frequency. For HD 24712 only models which are hotter by about 100 K and less luminous by nearly 10% than what is actually the most probable value would have an acoustic cut-off frequency large enough.

One may thus speculate that the old controversy about a mismatch between observed largest frequencies and theoretical cut-off frequencies of roAp star models is resolved.

More details can be found in Audard et al. (1997)

1. Stellar models and cut-off frequencies

We have computed representative models for CP2 stars with the CESAM code (Morel 1997). Effects from a magnetic field are neglected in our stellar models.

As the displacement for low-degree modes is essentially vertical, we shall consider only radial modes and, because we investigate modes of high radial orders, we adopt the Cowling approximation to calculate the cut-off frequency. We have computed the acoustic cut-off frequency according to the 3 following formulations: Vorontsov & Zarkhov (1989), Gough (1986), and in the approximation of an isothermal atmosphere.

2. Results

The main properties of the roAp star HD 24712, based, among others, on a HIPPARCOS parallax, can be reproduced with models of $1.63 M_{\odot}$, $Z = 0.02$ and an age of about 900 Myr. We have also computed Hopf and Kurucz models with appropriate age for HD 128898 (α Cir). For the first time, a Kurucz model atmosphere was calculated with an opacity distribution function specific to the composition of α Cir (Piskunov & Kupka 1997). Stellar models with $1.93 M_{\odot}$, $Z = 0.03$ and an age of 400 Myr, fit the observed values. For α Cir (HD 128898), models well within the error box can be found with a cut-off frequency which matches the observations. A similar situation exists for HD 134214 which, unfortunately, has a considerably larger error box. However, for HD 24712 only models in the lower left corner of the error box fit.

Due to uncertainties in the observations and the theory, models of different mass and age can fit the same star in the H-R diagram within the error box. Evolutionary tracks and lines of constant cut-off frequency for Kurucz models are plotted in Fig. 1.

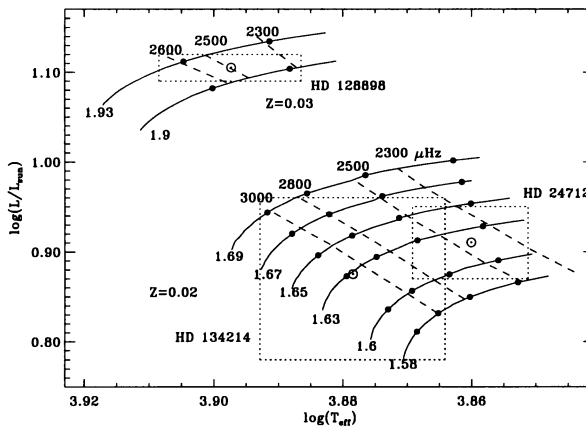


Figure 1. HR diagramme for stars with $1.58 M_{\odot}$ to $1.69 M_{\odot}$ ($Z = 0.02$), and with 1.90 and $1.93 M_{\odot}$ ($Z = 0.03$). Dots indicate ages of 400, 600, 800 and 1000 Myr for $Z = 0.02$, and 400 and 600 Myr for $Z = 0.03$. The roAp stars are indicated by circles and error boxes. Dashed lines of constant cut-off frequency in μHz are drawn for Kurucz models.

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