OSCILLATIONS OF LONG-PERIOD VARIABLES

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Abstract. We have performed a linear pulsational stability survey of long period variable models. The dynamic and thermodynamic couplings between convection and oscillations are treated by using a statistical theory of non-local and time-dependent convection. The results show that the fundamental and all the low overtones are always pulsationally unstable for the low-temperature models when the coupling between convection and oscillations is ignored. When the coupling is considered, there is indeed a "Mira" pulsationally instability region outside of the Cepheid instability strip on the H-R diagram. The coolest models near the Hayashi track are pulsationally stable. Towards high temperature the fundamental mode first becomes unstable, and then the first overtone. Some of the 2nd -4th overtones may become unstable for the hotter models. All the modes higher than 4th ($n > 4$) are pulsationally stable. The position and the width of such an instability region on the H-R diagram critically depends on the mass, luminosity and metal abundance of the star.

1. Conclusions and Discussion

By using a nonlocal and time-dependent theory of convection, we have very carefully treated the coupling between convection and oscillations. The linear stability analysis for luminous red stars gives us the following results:

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1. The coupling between convection and oscillations is the dominant factor for the pulsational instability, which favours estabilishing a Mira instability strip outside the Cepheid instability strip;
2. Except for some slightly hotter models which may have pulsationally unstable second to fourth overtone modes, luminous red variable stars pulsate in the fundamental mode or the first overtone. All the modes higher than 4 are pulsationally stable;
3. For the low-temperature red stars, the dynamic coupling between convection and oscillations is in the same order of magnitude as the thermodynamic coupling, and may even overtake the later;
4. The effect of turbulent viscosity grows very quickly towards high overtones for the luminous red stars. For high overtones, it becomes the main damping mechanism.

As for the long disputed pulsational mode for o Ceti, some authors think that o Ceti is pulsating in the first overtone, while some others believe that it oscillates in the fundamental mode. Following our numerical results, there is no model for which the first overtone pulsation constant exceeds 0.045 days. Normally, $Q_1 \leq 0.041$. Assuming for o Ceti, $M \approx M_\odot$, $T_e = 2900K$ (Wood P.R. 1990a, 1990b) and that it pulsates at the first overtone, then we have $L \approx 12500L_\odot$ or $M_{bol} \approx -5.5$. This would make it 0.7^m more luminous than the value of $M_{bol} = -4.8$ given by the P-L relation for Miras in the Large Magellanic Cloud (Glass *et al* 1987, Hughes & Wood 1990). This is unlikely to be real. Wood(1990b) proposed that if Mira's P-L relation depends on the metal abundance, then the discrepancy between the observed and the theoretical Q values could be removed. Our results of linear pulsational stability survey support Wood's guess. The instability strip moves indeed towards low temperature as the metal abundance increases. Following our linear stability analysis, it appears more likely for o Ceti pulsates in the fundamental mode than in the first overtone.

The details of the present study are given in our recent papers (Xiong *et al* 1997a, 1997b).

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