THEORETICAL NONRADIAL PULSATION OF β CEPHEI MODELS

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The excitation mechanism for the pulsations of β Cephei stars and variable B stars is not yet understood. Recently, Stellingwerf (1978) found that an opacity bump located near the He^+ ionization zone has a significant effect on the stability of radial pulsations in massive stars. However, the opacity bump, according to current opacities, is probably not enough to excite radial pulsations. On the other hand, some observational facts suggest that nonradial pulsations may participate in the variations of β Cephei stars and variable B stars. Therefore, it is interesting and important to examine the effect of the opacity bump on nonradial pulsations in massive stars.

Figure 1 shows the loci of the observed β Cephei stars in the H-R diagram and evolutionary models with X=0.70 and Z=0.03. The hydrogen-

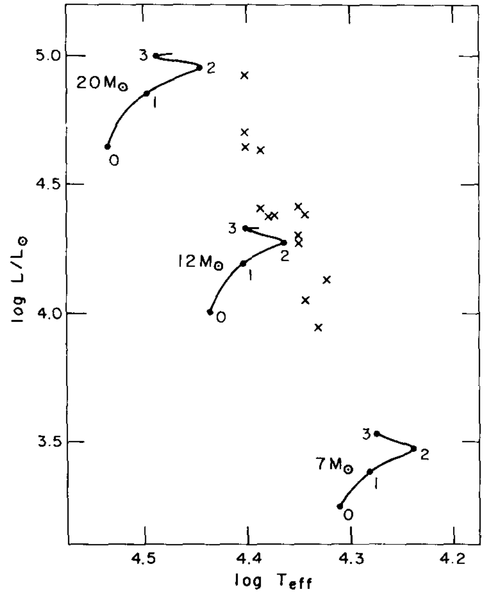

Fig. 1. β Cephei stars (×) and evolutionary tracks (X=0.70, Z=0.03) on the H-R diagram.

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exhaustion phases of the computed models are located near the observed instability strip of β Cephei stars. We applied a linear nonadiabatic pulsation analysis to the models indicated by numbers in Fig. 1. Details of the analysis are available in Saio and Cox (1979). Nonadiabatic periods are essentially the same as the adiabatic ones. The phase difference between maximum temperature and maximum luminosity is small in agreement with observations of β Cephei stars. Although all the modes investigated are stable, the opacity bump considerably affects the stability of nonradial pulsations as well as radial pulsations for some models. The most effective destabilizing region for the opacity bump in the H-R diagram is somewhat redder than the observed instability strip of the β Cephei stars (Stellingwerf 1978). Therefore, the destabilization by the opacity bump is most effective in the stage 2 models in our analysis. To quantify the destabilizing effect of the opacity bump we calculate the normalized growth rate, $\eta' = \int (\oint PdV)dm / \int |\oint PdV| dm$ introduced by Stellingwerf (1978). Relatively large values of η' mean that the destabilization by the opacity bump is relatively effective, and negative values of η' mean damping of pulsations. Some values of η' are listed in Table 1 for the radial fundamental and first overtone modes and for two nonradial modes (f and lower g^+ modes). The destabilizing effect of the opacity bump on non-radial pulsations is comparable to the effect on radial pulsations. The effective temperatures of the 20 $M_\odot$ models are too high for the opacity bump to work as a destabilizing agent for radial or nonradial pulsations. We can conclude that the opacity bump near the He^+ ionization zone as given by current opacities is not enough to excite any pulsations (radial or nonradial) in the β Cephei models.

Table 1. Normalized growth rate η' for stage 2 models

ℓ	mode	7 $M_\odot$ π (hour)	7 $M_\odot$ η'	12 $M_\odot$ π (hour)	12 $M_\odot$ η'	20 $M_\odot$ π (hour)	20 $M_\odot$ η'
0	F	4.661	-0.45	6.289	-0.89	9.488	-1.00
0	1H	3.557	-0.64	4.802	-0.97	7.229	-1.00
2	f	4.515	-0.46	6.326	-0.89	9.721	-1.00
2	g^+	5.826	-0.41	7.164	-0.88	9.236	-1.00

References

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