NEW OPACITIES AND FIRST OVERTONE MODE CEPHEIDS

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Abstract. Some results of linear adiabatic and nonlinear pulsation models of first overtone mode Cepheids are discussed. New and augmented opacities and a nonstandard mass-luminosity relation have been taken into account. The models indicate the possible importance of the resonance $P1/P4 = 2$ near $P1 = 3$ days. The resonance could explain the observed characteristics of the light curve shape of first overtone mode Cepheids.

There are several first overtone mode pulsators among short period Cepheids (Antonello et al., 1990a, 1990b; Simon, 1990). The analysis of their light curves has yielded Fourier parameters showing trends and a discontinuity which suggest that a resonance phenomenon between pulsation modes must be present in a way similar in part to that found in classical Cepheids with period near 10 days. The resonance for the first overtone mode Cepheids should be of the type 2:1 between the first and the fourth overtone, and should be centered at $P1 \sim 3$ days. Up to now, however, there was no clear evidence of it from theoretical models. Petersen (1989) suggested that the possible solution of his problem should be given by the use of increased metal opacity.

The recent work by Moskalik et al. (1991) indicated that the new, increased opacities (Iglesias and Rogers, 1991) are able to reproduce the period ratios of double-mode Cepheids, and these opacities along with a non standard mass-luminosity relation (Chiosi, 1990) are able to reproduce very well the observed pulsational characteristics of fundamental mode Cepheids. We have introduced the new opacities in a LNA code of T. Aikawa in order to check the possible presence of the resonance in the first overtone mode pulsators, and we have adopted the mass-luminosity relation for full overshoot models. The linear adiabatic results for the fundamental mode pulsators are comparable with those obtained by Moskalik et al.; moreover, there is evidence of the $P1/P4 = 2$ resonance for models with $4M_\odot$ and $P1 \sim 3$ days. In other words, a comparison of linear adiabatic results with the observations shows that the models with luminosities and effective temperatures comparable with those of observed stars predict the resonance for fundamental mode pulsators with P0 in the range between 9.2 and 10.8 days, and the resonance for first overtone mode pulsators with P1 in the range between 3.2 and 3.5 days.

A further test has been done by Aikawa (these proceedings) with nonlinear models. In this test, augmented old opacities by a factor of 5 instead of the new opacities have been adopted. The effects of the augmented opac-

Astrophysics and Space Science **210**: 331–332, 1993.

ities by this factor should be analogous to those of new opacities (see e.g. Renzini, 1990). The model sequence consisted of some models with $4M_{\odot}$, with the same luminosity, $1316L_{\odot}$, and different effective temperatures in the range 5400–5900 K. The results of this test are very interesting, because for the first time it has been possible to obtain realistic light curves with small amplitude (0.4 mag) of first overtone mode Cepheid models. Moreover, the light curves suggest the presence of a Hertzsprung-like progression which is related to the resonance P1/P4. The preliminary results indicate that the Fourier parameter R_{21} is low, less than 0.16, in agreement with the observations, while the parameter ϕ_{21} is generally larger by 0.5–1 rad than the observed one; moreover, the theoretical discontinuity in ϕ_{21} is small, 0.25 rad, in comparison with the observed one (1.5 rad). The theoretical resonance is centered at $P \sim 3.5$ days, while the observed center locates at about 3.2 days. There is an apparent clustering of the points in a narrow period range (2.9–3.9 days), which is explained by the use of a sequence of models with the same luminosity; we expect an improvement by using a sequence of models which runs approximately parallel to the blue edge (a similar sequence is also suggested by the observations; Antonello et al., 1991).

The results summarized in the present note will be discussed in detail elsewhere (Antonello and Aikawa, in preparation).

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https://doi.org/10.1017/S0252921100014391 Published online by Cambridge University Press