THE COUPLING COEFFICIENTS OF PULSATION FOR RADIATIVE STELLAR MODELS

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Abstract. The second order theory of coupling is discussed regarding the radial pulsation of stellar models which are constructed ignoring convection. The formula including the nonadiabatic effect is presented. Numerical values given for model classical cepheids are considerably greater than the adiabatic values.

The interaction between different oscillation modes is important for studying the real stellar pulsation. The coupling is studied by Schwarzschild and Savedoff (1949) for polytropic gas spheres. Takeuti and Aikawa (1981) studied the coupling coefficients of realistic cepheid models. Their values are not so different with those of polytropic models. Both these papers treated only the coupling in adiabatic oscillation, so that only the effect of adiabatic changes of pressure of a mode on another mode is considered. In the real stellar pulsation, the pressure change is dominated not only by the adiabatic component, essentially the effect of density change, but also by the nonadiabatic change which is caused from the change of temperature or the entropy.

Complete study of coupling is performed by Buchler and Goupil (1984) including nonadiabatic effect. Their formulation is complete but is difficult to use for estimating the coupling before hydrodynamic simulation. So the nonadiabatic coupling only based on the linear calculation should be studied. We assumed a common time dependency for the density and the entropy change. Then we have the following expressions :

$$x(r_0,t) = \xi(r_0)q(t), \tag{1}$$

and

$$y(r_0,t) = \eta(r_0)q(t), \tag{2}$$

where

$$x(r_0,t) = \frac{\delta r}{r_0}, \tag{3}$$

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and

$$y(r_0, t) = \frac{\delta s}{c_{V0}}. \tag{4}$$

We denote here the change of radius as δr, and the change of entropy as δs. r_0 and c_{V0} are the radius and specific heat at the equilibrium state, respectively.

Since we use the linear pulsation for determining $x(r_0)$ and $y(r_0)$, the pulsation function ξ may similar to the eigenfunction of Sturm-Liouville problem. This is also crucial assumption in our study. When we assume such an idealized condition on ξ, a lot of higher order terms is canceled by its orthogonality. We may easily obtain the effect of the entropy change on the other mode. The most important results of this calculation is that the coupling coefficients become greater in the order of 2 than those of adiabatic approximation. This comes from the strong nonadiabatic effect in the critical zone of hydrogen ionization. This effect may be removed when we use the models including the effect of convection.

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