Effects of moderate rotation on stellar pulsations, nonperturbative methods

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ABSTRACT

We present two approaches which have been considered in the asteroseismology team of the Institute of Astrophysics and Geophysics of Liège to take into account the effects of rotation on stellar pulsations by nonperturbative methods.

When the angular velocity of the star is much lower than the pulsation frequency of a nonradial mode, the splitting of the frequencies may be computed by a perturbative technique (Ledoux 1951 or textbooks like that of Cox 1980). This approach is particularly simple as it requires no extra computation. In case of moderate rotation, nonperturbative methods must be used. Two approaches have been considered.

The first project is conducted by M. Briquet. She is studying SPB variables. The rotation periods of these stars may be of the same order as the observed pulsation periods. In these conditions, a nonradial pulsation mode can no longer be described by a single spherical harmonic function $Y_{\ell m}(\theta, \phi)$ but is given by an infinite series of terms of this type with a given m but an infinite set of ℓ values (Zahn 1966). The linear pulsation equations then form an infinite system of coupled differential equations. At the cost of a few approximations, this infinite system can be broken into uncoupled pairs of differential equations having a form similar to that of the nonrotating case (Berthomieu et al. 1978 and Unno et al. 1989). This theory is well established, and M. Briquet plans to include it in our stellar stability codes.

The second project is due to C. Neuforge. In collaboration with R.G. Deupree, J.A. Guzik and P.A. Bradley, she plans to calculate a grid of 2-D rotating stellar evolution models (Deupree 1998) suitable for the mass range of the δ Scuti stars (1.5–2.5 $M_{\odot}$), with and without convective core overshooting. Then she will compute their oscillation frequencies. She will first adopt a variational approach (Lynden-Bell and Ostriker 1967 and Clement 1989). This approach does not give any information about the stability of the computed modes. The next step will be the implementation of a 2-D program solving the pulsational stability equations.

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