Astrophysical Applications of Stellar Pulsation
ASP Conference Series, Vol. 83, 1995
R. S. Stobie and P. A. Whitelock, eds.

On the Mechanism of Mode Selection in Rapidly-Oscillating Magnetic Ap-Stars

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Abstract. We address the problem of the preferential mode excitation in magnetic Ap-stars by estimating the pulsation energy losses in the atmosphere through the generation of the Alfvenic waves.

Most oscillations of magnetic Ap stars are identified as dipole ($\ell = 1$) modes, with the symmetry axis aligned with magnetic axis. The preferential excitation of this mode might be provided by some selective properties of the excitation mechanism itself (Dolez & Gough 1982, Shibahashi 1983, Dziembowski 1984, Dziembowski & Goode 1985, Dolez et al. 1988). An alternative explanation related with the magnetically-induced lateral inhomogeneity of the acoustic cut-off frequency, was considered by Shibahashi (1991).

It was first demonstrated by Roberts & Soward (1983) and Campbell & Papaloizou (1986), that wave transformation in the magnetic atmosphere can provide a significant dissipation of the acoustic mode energy. For acoustic waves which propagate almost vertically near the surface, the generation of Alfvenic waves requires the magnetic field to have both a horizontal and vertical component. We thus expect the acoustic energy losses to be localised in two belts which are symmetric around the magnetic equatorial plane. These simple qualitative arguments suggest that $\ell = 1$, $m = 0$ mode with maximum amplitudes in polar regions might suffer smaller energy losses than $\ell = 1$, $m = 1$ mode. Our quantitative estimates are based on the perturbation analysis developed by Roberts & Soward (1983). Their result for the relative loss of the acoustic energy flux in the polytropic atmosphere of index n can be written as

$$\tilde{R}^2 \propto B_x^2 \left(B_z^2\right)^{\frac{1}{n+2}} , \tag{1}$$

where B_x and B_z denote the horizontal and the vertical component of the magnetic field. For a centred dipole field,

$$\tilde{R}^2 \propto \sin^2\theta \left(\cos^2\theta\right)^{\frac{1}{n+2}} . \tag{2}$$

Note that the perturbation analysis of Roberts & Soward (1983) breaks down when $B_z \ll B_x$, i.e., near the magnetic equator. The correct analysis remains to be developed; it is reasonable to expect, however, that a more accurate description of $\tilde{R}(\theta)$ in the equator region will not change the qualitative conclusions.

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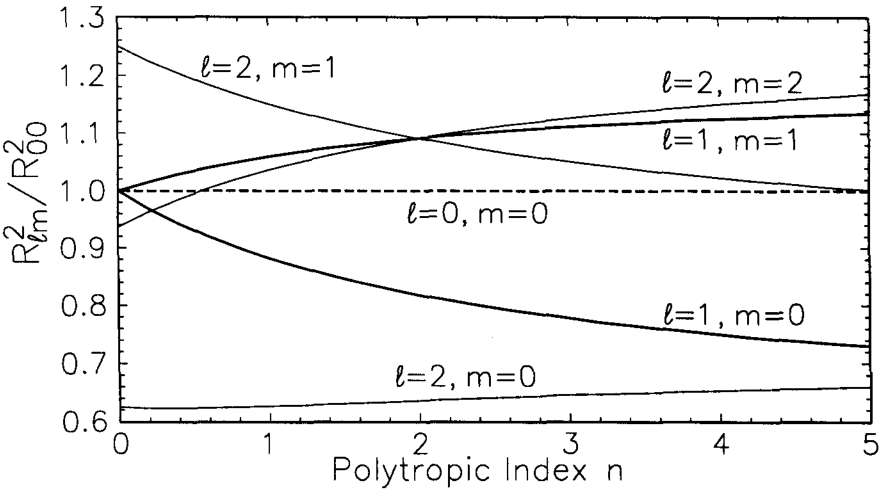

Figure 1. Energy dissipation compared with that of $\ell = 0$ mode.

The integral energy losses are estimated by the integration of $\tilde{R}^2$ with pulsation amplitudes. The energy losses of $\ell = 1$, $m = 0$ mode appear to be smaller than those of $m = 1$ mode for all $n > 0$ (Fig. 1). The energy losses are also smaller than those of a radial mode, which is in agreement with the observational evidence that dipole, but not radial modes are predominantly excited. It is interesting that for $\ell = 2, m = 0$ mode the energy losses appear to be even smaller, so that it is even more competitive for being excited. The last conclusion, however, is more sensitive to the correct treatment of the magnetic effects near the equator.

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