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# Influence of a Uniform Coronal Magnetic Field on Solar $p$ Modes: Coupling to Slow Resonant MHD Waves

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**Abstract.** The influence of a constant coronal magnetic field on solar global oscillations is investigated for a simple planar equilibrium model. The model consists of an atmosphere with a constant horizontal magnetic field on top of a unmagnetized solar interior. The focus is on the possible resonant coupling of global solar oscillation modes to local slow continuum modes of the atmosphere and the consequent damping of the global oscillations.

## 1. Introduction

$P$ modes are acoustic waves trapped in the upper layers of the Sun. The cavity is basically determined by the profile of the sound speed in the solar interior, but the oscillations can penetrate into the lower layers of the atmosphere and so are influenced by those layers. The atmospheric effects are not large, because the oscillations are predominantly determined by the internal structure of the Sun, but they are distinct. Magnetism is important in the Sun's atmosphere and is expected to influence the nature of global oscillation modes too.

In ideal MHD the resonant waves occur as a singularity in the differential equations governing the linear oscillations. The solutions diverge at the resonance point. The singularities in the ideal equations can be removed by including dissipative terms. Here, the model allows us to treat the resonance analytically without the need of including dissipative effects.

## 2. General equations

Linear isentropic harmonic perturbations with angular frequency $\omega$ and horizontal wave number $\mathbf{k} = k\mathbf{1}_x$ are imposed on an equilibrium model with a straight magnetic field in the $x$-direction. The two linear first-order differential equations for the $z$-component of the displacement, $\xi_z$ and the Eulerian perturbation of total pressure, $P$ are (Vanlommel & Goossens, 1999):

$$D\frac{\mathrm{d}\xi_z}{\mathrm{d}z} = C_1\xi_z - C_2P \quad \text{and} \quad D\frac{\mathrm{d}P}{\mathrm{d}z} = C_3\xi_z - C_1P_T, \tag{1}$$

with $D$, the coefficient of the highest order given by

$$D = \rho_0(v_s^2 + v_a^2)(\omega^2 - \omega_c^2). \tag{2}$$



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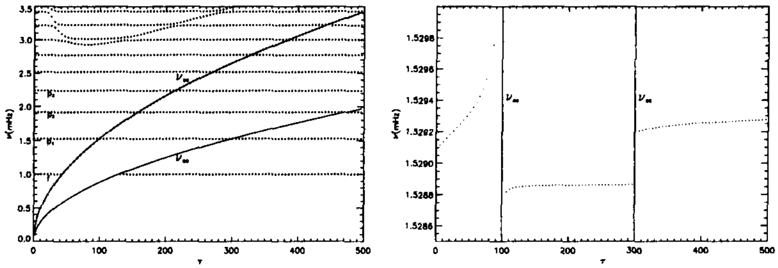


Figure 1. (a) Frequency as function of the temperature jump $\tau$. (b) The frequency of the first $p$ mode is shown as function of $\tau$.

Here, $v_s$ is the sound speed, $v_a$ the Alfvén speed, and $\omega_c$ is the cusp frequency. It depends on $z$ and defines the slow continuum. Global oscillations with a frequency in this continuum can be resonantly absorbed. A thorough discussion about how to deal mathematically with the resonances can be found in Vanlommel et al. (2001).

## 3. Results

Fig. 1 (a) shows the dependence of the real part of the frequency of the modes on the temperature jump $\tau$ between the atmosphere and the solar interior. The domain where resonances occur lies again between the two curves $\nu_{sc}$ and $\nu_{cc}$. The magnification in Fig. 1 (b) shows how the frequency of the $p_1$ mode is shifted as a consequence of the resonance. The resonance makes the frequency complex and therefore damps the mode.

## 4. Conclusions

The result of the resonant coupling with cusp waves is twofold. The eigenfrequencies become complex and the real part of the frequency is shifted. The shift of the real part of the frequency is not negligible and within the limit of observational accuracy. This indicates that resonant interactions should definitely be taken into account when calculating the frequencies of the global solar oscillations.

## References

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