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Excitation of Solar p-mode Oscillations by Flares

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Abstract. Solar flares release large amounts of energy at different layers of the solar atmosphere. It is, therefore, expected that major flares would be able to excite waves, thereby affecting the p-mode oscillation characteristics. From the analysis of MDI data, we find that power in p-modes appears to increase for some flares, beyond the normal values expected from the influence of magnetic field.

Wolff (1972) suggested that flares could excite solar oscillations as a result of the mechanical impulse produced by the thermal expansion exerted towards the solar interior. Haber et al. (1988) found 5% greater power in outgoing than in the incoming waves in an active region during a large flare. On the other hand, Braun and Duvall (1990) found no conclusive power enhancement. More recently, Kosovichev & Zharkova 1998 have reported that a large flare may indeed have excited waves on the solar surface. In order to further study this important problem, we have selected eight flaring active regions of different magnetic complexities observed during the period 1998–2001. We use the ring diagram technique (Hill 1988) applied to 3D spectra obtained from the MDI/SOHO data Each of the selected MDI data sets covers an area of about $16^\circ \times 16^\circ$ on the active regions, and a time interval of 1664 minutes. We have chosen the data from available sets when the active regions were close to central meridian in order to reduce the projection effects. To fit the 3-D spectra we have used a model with asymmetric peak profiles (Basu & Antia 1999). We calculated daily net flare indices, *FI*, for the selected active regions using the method described by Atac & Ozguc (1998). Furthermore, magnetic index *MAI* for the active regions is calculated by using the method described in Rajaguru et al. (2001). It is to be noted that large MAI leads to significant amount of absorption of p-mode power, while large flares are expected to provide amplification of the p-modes. Therefore, any flare-related change in mode characteristics would be a net result of these counter effects. We have found that in almost all the active regions studied by us, the power in acoustic modes appears to increase beyond the normal value because of flaring activity, once the decrease in power due to the presence of high magnetic fields was accounted for (Figure 1). However, the extent of power enhancement is not well-correlated with

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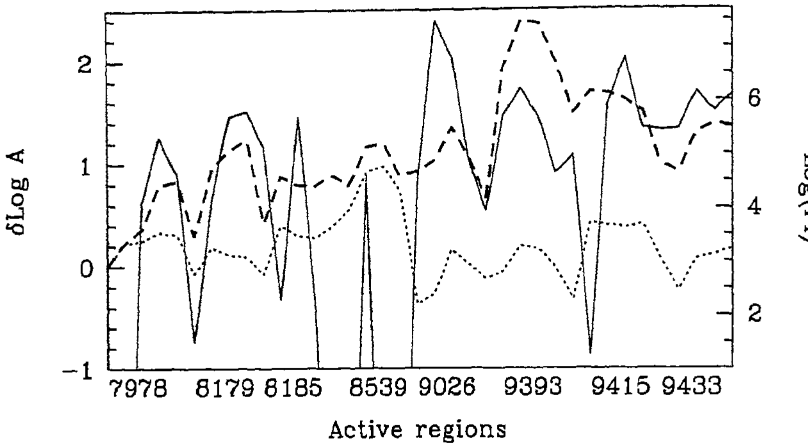

Figure 1. Variation in average mode amplitude A obtained for the 8 active regions as marked along the x-axis. The solid curve shows $\log(FI)$ on a scale marked on the right axis, while the dotted curve represents $\delta\log(A)$ (all differences are taken with respect to a quiet region). The heavy dashed curve shows $\delta\log(A)$ after correcting for MAI.

the magnitude of FI. The observed variations in the effect of flares on oscillation modes may perhaps be attributed to the relative importance in depositing the flare energy at the photosphere. We find that a large X-class of flare alone is not an adequate indicator of this deposition, as this parameter is related mainly to the emission from higher, coronal level. On the other hand, a lower X-class, but higher H_α class of the flare may be more important.

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