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GONG p-mode frequency changes with solar activity

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Abstract. In this paper, we present a correlation study of nine solar activity indices with p-mode frequency shifts obtained from the GONG data. It is found that the two are closely correlated and a linear relationship exits. Further, the GONG p-mode frequencies for the period 1995 August to 1997 August show that the mean frequency decreases by 0.06 μHz during the descending phase of the solar cycle 22 and increases by 0.04 μHz in the ascending phase of the new solar cycle 23.

Key words : Sun : oscillations, Sun : activity

1. Introduction

It is now established that the oscillation frequencies vary with the solar activity cycle. In this context, we have looked for a possible correlation between the p-mode frequency shifts and nine solar indices representing the photospheric, chromospheric and coronal activities during the declining phase of the solar cycle 22 and the early phase of cycle 23.

The GONG data (Hill et al. 1996) used in this study consist of 8 data sets for GONG month (GM) 4 to 9 each of 36 days, GM 12-14 and GM 21-23 of 108 days each, covering a period from 1995 August to 1997 August in the frequency range between 1500 to 3500 μHz and l from 2 to 150. For calculating the frequency shifts, GM 12-14 is taken as the reference, as this period lies in the middle of the period covered in this study. We have included only those modes which are common in all data sets.

2. Analysis and results

The mean frequency shift is found from the relation :

$$\delta\nu(t) = \sum_{nl} (Q_{nl}/\sigma_{nl}^2)\ \delta\nu_{nl}(t) \,/\, \sum_{nl} (Q_{nl}/\sigma_{nl}^2) \qquad (1)$$

where Q_{nl} is the inertia ratio as defined in Christensen-Dalsgard and Berthomieu (1991), σ_{nl} is the error in frequency and $\delta\nu_{nl}(t)$ is the change in the measured frequencies for a given n and l. A mean value was computed for each of the nine activity indices over the corresponding

GONG month. To study the relative variation in $\delta\nu$ with activity index i, we assume a linear relationship of the form :

$$\delta\nu = ai + b, \tag{2}$$

where $\delta\nu$ includes the mean error in the measured frequencies. The slope a and intercept b are obtained by performing a linear least square ft. Figure 1. shows a typical plot of our analysis for all ℓ modes between 20 to 60. The solid line represents the best fit regression line and shows that the data is consistent with the assumption of a linear relationship. This relationship is further tested by calculating the parametric Pearson's coefficient r_p and their two sided significance P_p. The analysis confirms that a positive and linear correlation exists between the frequency shift and solar activity indices. Further, we find that the radiative indices are better correlated with $\delta\nu$ as compared to the magnetic indices.

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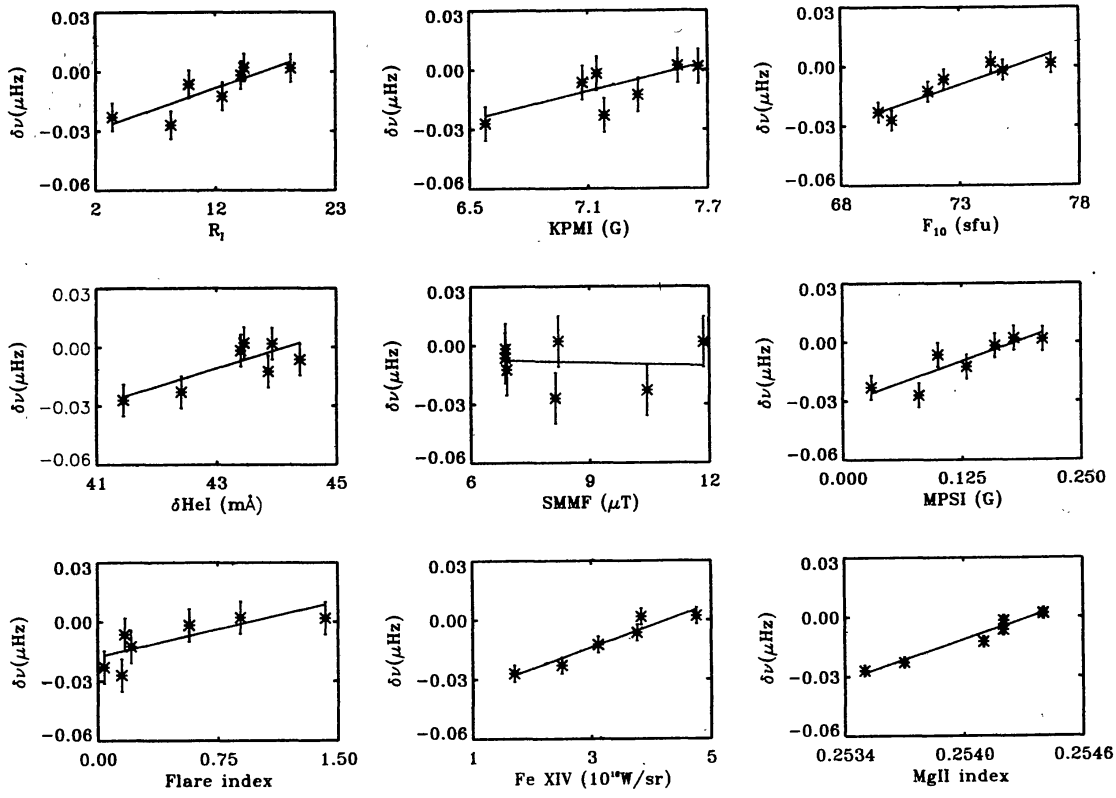

Figure 1. Comparison of weighted mean frequency shift for nine solar activity indices in the ℓ range of 20 to 60. The solid line represents the linear fit. The error bars represent 1σ error of the fitting.