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On the p-mode Asymmetry between Velocity and Intensity from the GONG+ Data

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Abstract. We have analyzed the local acoustic spectra of small regions over the solar surface at different locations from disk center to limb via the technique of ring diagrams. The analysis suggest that the frequency shifts between velocity and intensity is a function of location on the disk and is higher near the disk center than those near the limb.

The peaks of solar oscillation *p*-modes observed in velocity and intensity spectral lines are asymmetric (Duvall et al. 1993). Moreover, this asymmetry is reversed; velocity (V) has negative asymmetry (more power on the low frequency side) while intensity (I) power spectrum has positive symmetry (more power on the high frequency side). Roxburgh and Vorontsov (1997) have suggested that the reversal in asymmetry occurs in velocity while the observations suggest that the reversal occurs in intensity (Nigam et al., 1998). In a phenomenological model, Nigam et al. (1998) proposed that the reversal is due to the correlated background noise whose level depends on the characteristic granulation. Recently Georgobiani et al. (2002) have proposed that the asymmetry reversal is produced by radiative transfer effects and not by correlated noise. In addition, a recent study of center to limb variation (CLV) of solar granulation reports that the granulation contrast increases near the limb (Sanchez Cuberes et al., 2003). Since, the physics of the correlated noise is not yet fully understood, it is desirable to test these ideas using a different data source such as GONG+ which now provides high resolution Dopplergrams of the Sun at each minute interval.

The data used here consist of velocity and intensity images obtained by the prototype GONG+ instrument at Tucson for the period June 11-13 and 15, 2000 and GONG+ instrument at BBSO during May 25-27 and 29, 2001. The disk center (-7.5^0 to 7.5^0) and four areas in longitude from 15^0 to 60^0 (at an interval of 15 degrees) each of 15 x 15 degrees are extracted and tracked and remapped on to a grid of 128 x 128 pixels. A 3D FFT (Hill, 1988) was used to obtain the power

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as a function of (ν, k_x, k_y). The power spectrum of each individual day are then combined to enhance the signal. We further take an azimuthal average around the rings to bring out the peaks in the power spectra and rescale the spectra to the interval [0,1]. Figure 1 shows the velocity and intensity spectra as a function of frequency for different regions across CLV. We note that at low degrees, the asymmetry agrees with the earlier studies, velocity and intensity has more power on the low and high frequency side respectively. For the disk center, we also find a frequency shift between V and I above the cutoff frequency of 5.3 mHz which is consistent with those of Nigam et al. (1998) and Jain et al. (2003). Although, the resultant spectra are not corrected for the small projection effect, there is evidence that the power amplitude is higher near the disk center and decreases towards the limb. Similarly, the frequency shift between V and I at higher frequencies appears to decrease from disk center to limb.

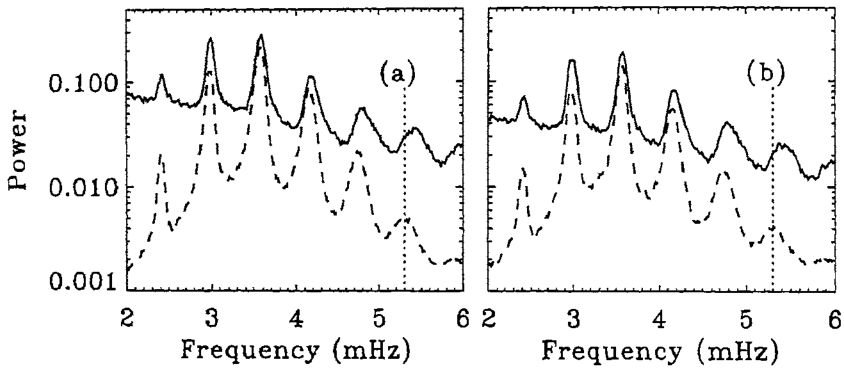

Figure 1. The intensity (solid line) and velocity (dashed line) power spectra as a function of center to limb at $\ell = 578$ for the GONG+ data from Tucson station. The panels denote the following starting longitudes: (a) -7.5°, (b) 30°. The vertical thin dotted line is at 5.3 mHz.

Since the apparent frequency shift between an oscillation observed in velocity and intensity cannot be a property of the mode, it must arise from the excitation mechanism. In addition, the observed decrease of the V-I frequency shift from center to limb strongly suggests that the mechanism is that of correlated noise from the granulation rather than radiative transfer effect. At disk center we observe the vertical velocity field, which has both oscillatory and granulation contributions. Near the limb we see primarily the horizontal velocity field which is dominatd by granulation. This decreases the correlation with the oscillations and thus apparently reduces the frequency shift. We plan to improve the analysis to include additional data, and to quantify the result which will be used to test models of the mode excitation and damping mechanism.

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References

Duvall, T. L., Jr., Jefferies, S. M., Harvey, J. W., Osaki, Y., Pomerantz, M. A., 1993, *Astrophys. J.*, **410**, 829.

Georgobiani, D., Stein, R. F., Nordlund, A., 2002, astro-ph/0205141.

Jain, K., Hill, F., Toner, C., 2003, In Tripathy, S. C. and Venkatakrishnan, P., editors, *Probing the Sun with High Resolution*, Narosa Publishing House, New Delhi, page 31.

Hill, F., 1988, *Astrophys. J.*, **333**, 996.

Nigam, R., Kosovichev, A. G., Scherrer, P. H., Schou, J., 1998, *Astrophys. J.*, **495**, L115.

Roxburgh, I. W., Vorontsov, S. V., 1997, *MNRAS*, **292**, L33.

Sanchez Cuberes, M., Vazquez, M., Bonet, J. A., Sobotka, M., 2003, *A&A*, **397**, 1075.