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On the power and frequency of p-modes in sunspots

Brajesh Kumar, S. C. Tripathy, Rajmal Jain and M. R. Deshpande

Udaipur Solar Observatory, Physical Research Laboratory, PO Box No. 198, Udaipur 313 001, India

Abstract. A time series of GONG Dopplergrams has been used to measure the velocity fluctuations in the sunspot and quiet photosphere simultaneously. The power spectrum analysis shows that the power of the predominant p-mode is reduced in the sunspot region by 36 to 51% as compared to the quiet photosphere. Our results also show a relative frequency shift of the power envelope of these modes of the order of 70 to 300 μHz.

Key words : Sun : Oscillations - Sun: photosphere - Sun : sunspots

1. Introduction

The study of intensity and velocity variations in and above an active region has been carried out by several investigators with successively improved observational techniques. Such studies are intended to understand the basic mechanism of the interaction of acoustic waves with the complex magnetic features. This can be done by measuring and quantifying the scattering properties of solar eigen-modes appearing in the form of changes in their amplitude, frequency and phase. Previous studies of these oscillations in sunspots in photospheric layers are contradictory and suggest a period of 300 and 310 sec differently (e.g. Beckers and Schultz 1972; Bhatnagar et al. 1972; Nye et al. 1981; Horn et al. 1997). In view of these contradictory results, we investigate the amplitude and frequency of solar p-modes in a sunspot as compared to the quiet photosphere.

2. Data reduction and analysis

We have used the GONG Dopplergrams of Udaipur station for five consecutive days between May 10-14, 1997 to measure the velocity fluctuations in the sunspot (NOAA AR No. 8038) and quiet photosphere simultaneously on the solar disk. Intensity images have been used to locate and follow the position of sunspot since a sunspot is not visible on the Dopplergram. The sunspot co-ordinates (3 × 3 pixels) are then translated onto the velocity images assuming one to one correspondence between the two image frames. The velocity fluctuations for each day are measured in the 3 × 3 pixel grid and then subjected to Fourier Transform to calculate the individual power spectrum. These power spectra are averaged to reduce the noise. For a comparative study, a similar procedure is adopted for the quiet region at nearly opposite longitude to account for the effect of limb foreshortening. To ensure the genuine peak power and corresponding frequency of the power envelope, a low pass digital filter, named Savitzky-Golay filter (Press et al. 1992), has been applied to the average power spectrum as shown in figure (1).

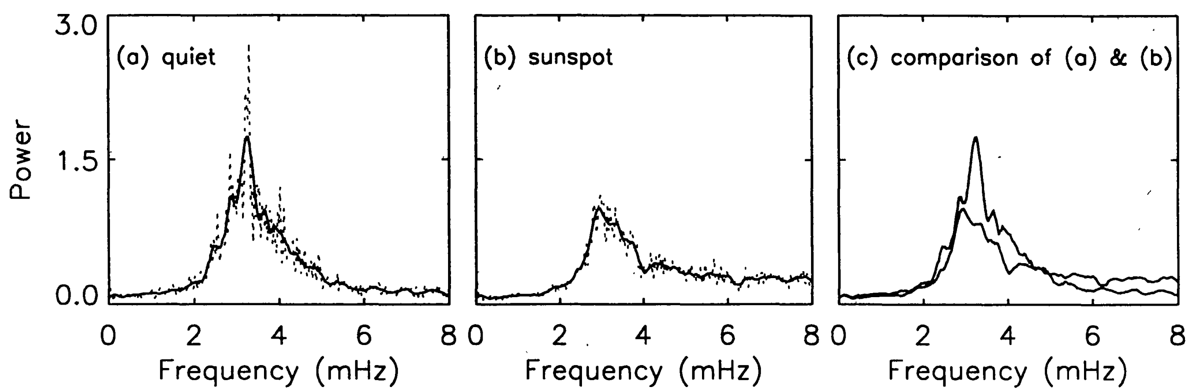

Figure 1. Average power spectrum for quiet photosphere and sunspot (dotted line) for 12 May, 1997 Udaipur site. The Savitzky-Golay filter fit to the both are shown in solid line. Power is in arbitrary units.

3. Discussion and conclusion

The power spectrum analysis clearly shows a relative reduction in amplitude of p-modes in the sunspot as compared to the quite photosphere for all the days. In addition, we also find that the power envelope shifts along the lower frequency side in the sunspot, the maximum being 300 μHz on 12th May, the day on which a flare occurred near the sunspot. It is expected that the power absorption in an active region should be nearly same for equal magnetic field strength (Hindman and Brown 1998). However, we also find a day to day variation in the p-mode power in the sunspot during May 10-14 although the magnetic field strength remained nearly same. The higher values are obtained for May 10 and 14, when the sunspot is farther from the centre. We conjecture that this variation may be due to the location and height of the sunspot and is being investigated.

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