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Oscillations of Sunspot Magnetic Fields: MDI Observations of a Symmetrical Sunspot

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Abstract. We report on sunspot magnetic field oscillations observed using the MDI instrument on the SOHO spacecraft. Clear oscillations are seen in both the 3- and 5-min bands, but appear to be intermittent.

1. Introduction

The reality of detected sunspot magnetic field oscillations is still controversial,and only few observations have been published reporting detections, or non-detections (Horn et al. 1997, Lites et al. 1998, Norton et al. 1998, Rüedi et al. 1998). In this paper we present results of a search for magnetic field oscillations in a regular, relatively symmetric sunspot.

2. Observations

The data presented here have been recorded on June 19, 1998 in the active region NOAA 8243 as it approached the central meridian. The data set consists of high resolution (0.605″pixel size) MDI magnetograms, velocitygrams and intensitygrams. A relatively circular sunspot was present in this region that did not undergo any change or movement (except due to solar rotation) during the interval covered by the analysed time series. The data presented here was sampled at a 1 minute cadence during 538 minutes, i.e. almost 8 hours. Figure 1 shows a sample image of this region. The approximate center of the sunspot, halfway through the timeserie, is located at 22″E 272″N.

3. Analysis and Results

The data have been smoothed over 7 pixels and split into 6 sequences, each 1.5 hours long. Power spectra of the velocity and magnetogram signal were computed, as well as their cross-power, coherence and relative phases.

Figure 2 depicts maps of the power of the magnetogram signal. The power signals lying above the 95% confidence level (as defined by Groth 1975) have been integrated over the frequency bands 2.96-3.88 mHz and 4.81-5.55 mHz. The six consecutive 1.5 hours sequences (a-f) are depicted. Localised power is present in both bands. These maps also clearly show the intermittency of the magnetogram power.

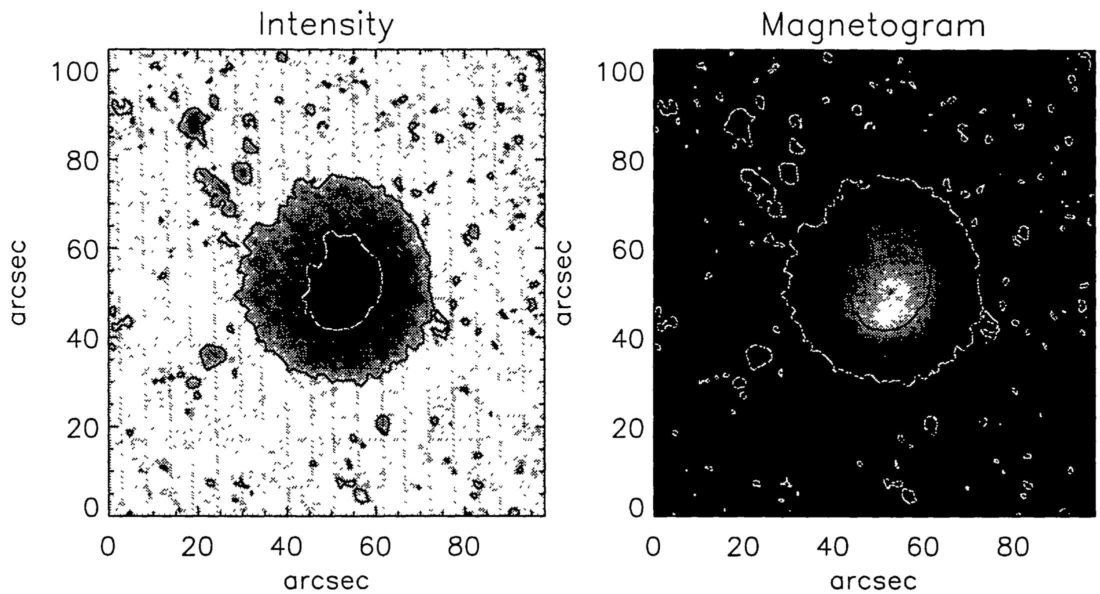

Figure 1. Sample intensitygram and magnetogram of the observed sunspot. The contour levels in both images mark the intensities corresponding approximately to the umbral and penumbral boundaries.

For example, consider the plots referring to the 3-min band. The strongest signal seen in the umbra appears in panel b, while it completely disappears in panel e. This suggests that the oscillations die out from time-to-time and are re-excited later. However, some positions in the sunspot seem to be favored. The position of the power peaks in the 3-min range corresponds approximately to the place showing the strongest magnetic signal in this sunspot. A similar result was found for another sunspot by Rüedi et al. (1998).

In the 5-min band the main power peak happens to be located at the same spatial position as the 3-min peak. The strength of the 5-min power peak also has a strong temporal variation, but this is not correlated to the temporal variation of the 3-min power peak. In the 5-min band some power is also observed in the penumbra, but it is roughly an order of magnitude lower than the strong umbral peak (the grey-scale used in Fig. 2 is missleading).

Although the strongest power in these 2 frequency bands is found at almost the same locations, almost no power is observed at adjacent locations, although these have otherwise similar properties, which suggests that this enhanced power is not simply due to enhanced noise at this particular location. This is illustrated in Fig. 3 were a sample power spectrum is plotted for the central position of the sunspot in time-series a. The dashed line corresponds to the 95% confidence level (Groth 1975).

Figure 4 shows again the power in the 5-min band for time-series b (c.f. Fig. 2). The second plot depicts the relative phase shift between the magnetogram and velocity oscillations. White tones correspond to a positive phase, i.e. the magnetic field oscillations lead the velocity oscillations, black tones to negative phase. Note that the grey background does not necessarily mean that the phase is 0 at those positions, since we artificially set it to 0 where the mag-

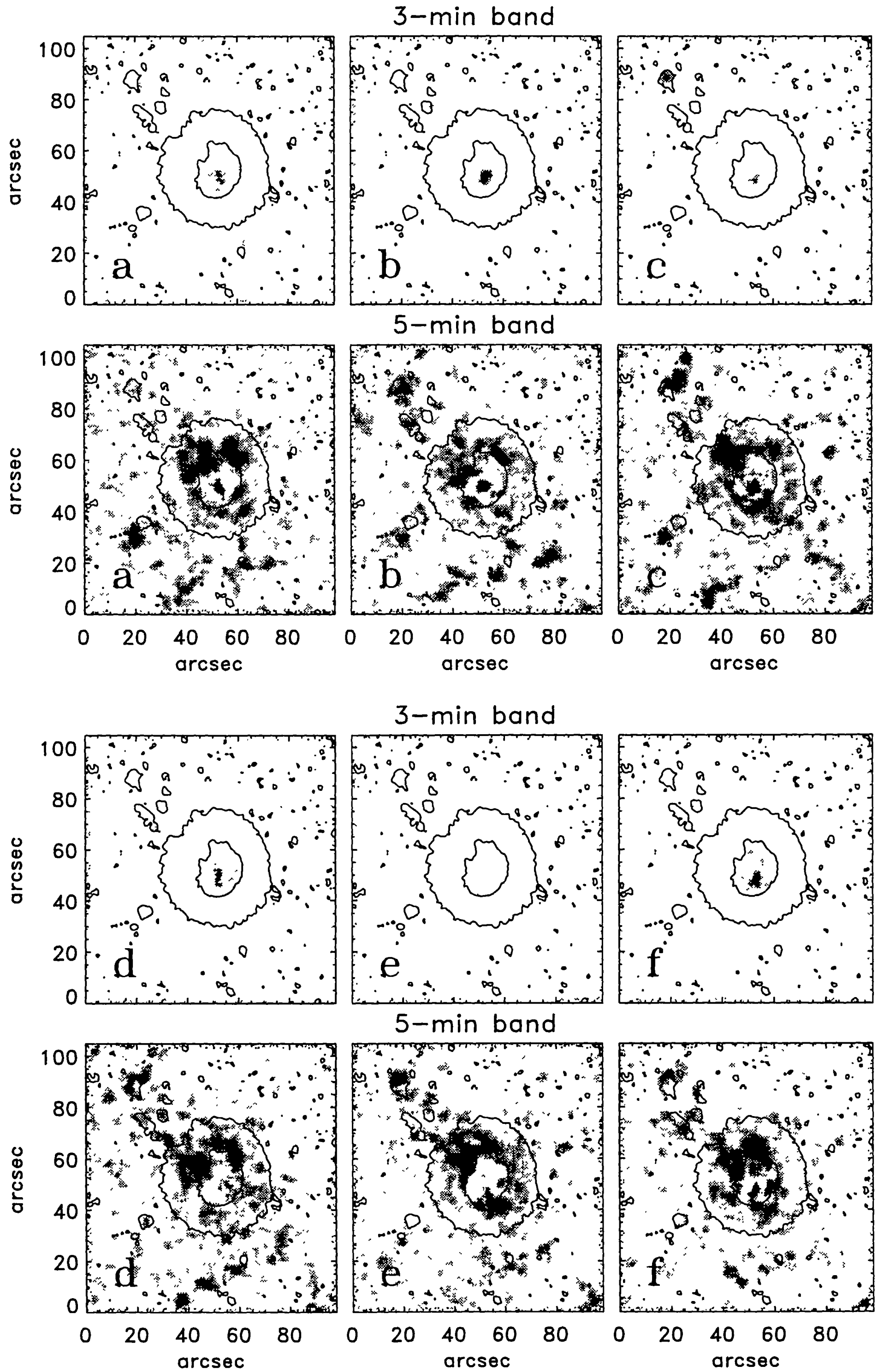

Figure 2. Maps of the power of the magnetogram signal above the 95% confidence level integrated over the frequency bands 2.96-3.88 mHz (5-min band) and 4.81-5.55 mHz (3-min band). Six consecutive 1.5 hours sequence (a-f) are depicted. The contour levels mark the approximate umbral and penumbral boundaries (same as in Fig. 1).

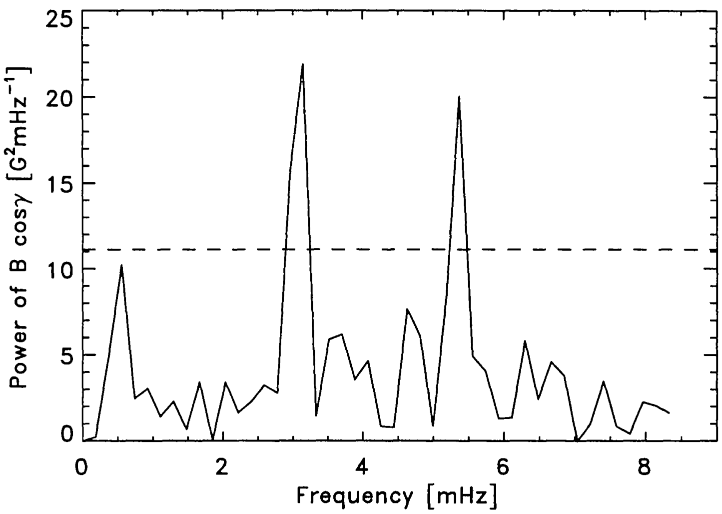

Figure 3. Power spectra of the magnetogram signal from the centre of the sunspot taken from the time-series a of Fig. 2. The dashed line corresponds to the 95% confidence level.

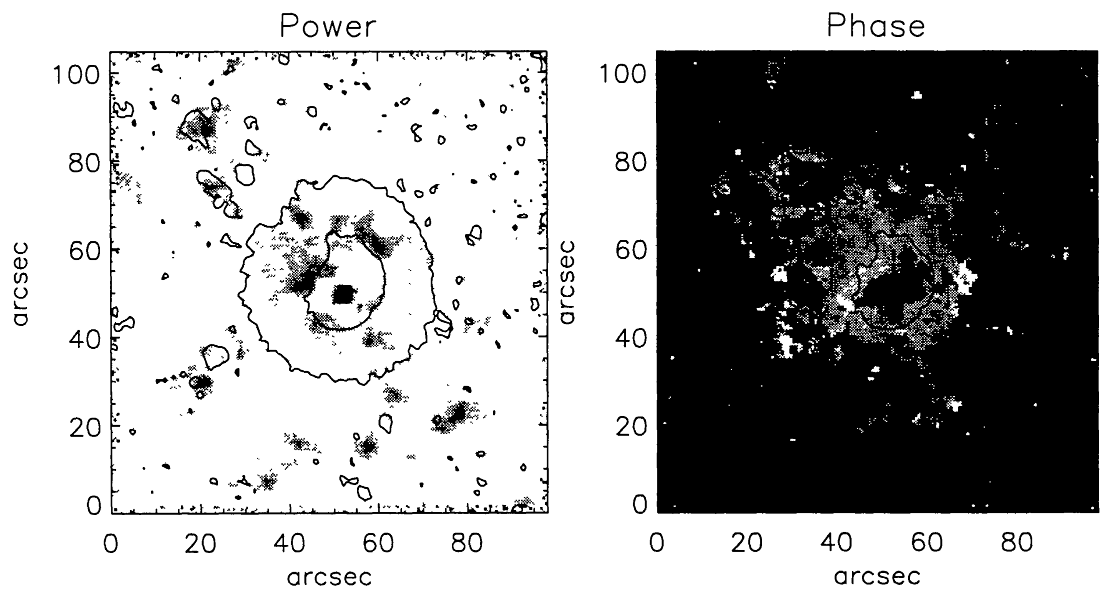

Figure 4. Maps of the power and phase corresponding to the time-series b of Fig. 2 for the 5-min band. In the phase map, bight tones correspond to positive phase (i.e. magnetic field oscillations leading the velocity oscillations).

netic power doesn't lie above the 95% confidence level, or where the coherence between the magnetic and velocity oscillations is below 0.7.

In the center of the umbra, the phase is -41°, while enhanced power in the penumbra is coupled to a positive phase. It is interesting to note that for every time-series the weak magnetic power observed in the penumbra invariably shows a positive phase ranging between 80°and 120°. The phase of the strong umbral power peak does not show such a steady behaviour, but varies around 0 between -41°(for timeserie b) and +55°(for timeserie c).

4. Conclusions

Observations of the present sunspot basically confirm the results found by Horn et al. (1997), Lites et al. (1998), Norton et al. (1998) and Rüedi et al. (1998). The MDI magnetogram signal shows significant power in the 5- and 3-minute bands at certain times and locations within a sunspot. The exact nature of these oscillations remains unclear, however. In a next step we therefore plan to study their relation with the velocity oscillations exhibited by the same sunspot and to compare these observations with the predictions of models.

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References

Groth E.J., 1975, ApJS, 29, 285

Horn T., Staude J., Landgraf V., 1997, Sol. Phys. 172, 69

Lites B.W., Thomas J.H., Bogdan T.J., Cally P.S., 1998, ApJ497, 464

Norton A.A., Ulrich R.K., Bogart R.S., Bush R.I., Hoeksema J.T., 1998, in: New Eyes to See Inside the Sun and Stars, F.-L. Deubner, J. Christensen-Dalsgaard, D. Kurtz (Eds.), Kluwer, Dordrecht, IAU Symp. 185, 453

Rüedi I., Solanki S.K., Stenflo J.O., Tarbell T., Scherrer P.H., 1998, A&A335, L97