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On the Rapid Variations of Solar Magnetic Fields

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Abstract. We report on the rapid variations of solar magnetic fields that appear to be enhanced significantly above the background variability, at a few locations within the solar active regions, as observed with the Michelson Doppler Imager (MDI) on board the *SOHO* spacecraft. The pressure fluctuations estimated to arise from this variability far exceed the general level of acoustic pressure fluctuations. The equivalent mechanical flux that could be generated from these rapid magnetic variations is more than adequate for the heating of the active region chromosphere and corona.

Keywords : Sun — MHD — photosphere

1. Introduction

The motivation for this study arose from earlier studies of the acoustic spectrum from magnetized regions of the Sun, which showed, along with a suppression of the regular 5 minute oscillations, an enhancement in power at higher frequencies (Venkatakrishnan, Kumar, & Tripathy 2002, and references therein). To search for the drivers of these higher frequency oscillations, we decided to look at the temporal behaviour of the magnetic fields using data obtained from the MDI instrument onboard the *SOHO* spacecraft. These are appropriate for a study of this kind because of the uniformity of sensitivity and absence of atmospheric seeing. There have been reasonable observational support of solar MHD modes (Settele, Sigwarth, & Muglach 2002, and references therein), but with varying results. In this paper, we have analysed 4-5 active regions with different magnetic morphologies, during their passage through the disk center using MDI magnetograms. Our results show that rms fluctuations of the magnetic fields are generally larger in strong field regions with rms values ranging between 40-70G for various active regions. Our results suggest that the observed magnetic field oscillations are the drivers of the high frequency velocity oscillations as seen in the high magnetic field locations on the Sun.

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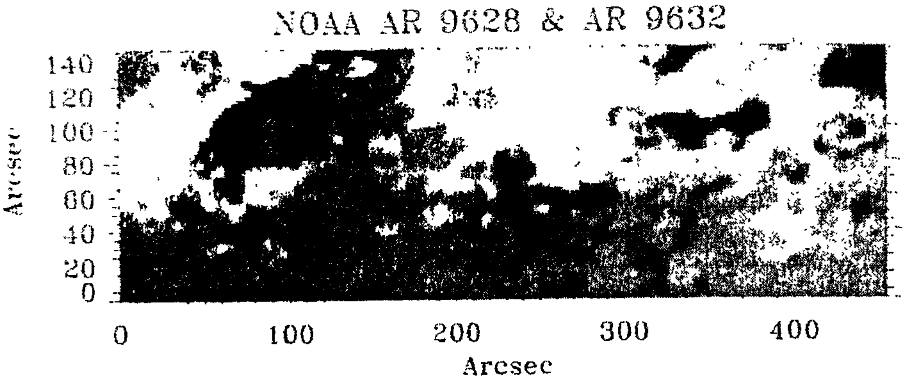

Figure 1. RMS of magnetic field variations are shown as contours overlaid on the mean magnetogram of the active region. The lowest and highest contour levels are 30G and 70G, respectively.

2. Data Analysis and Results

We chose the NOAA active regions 9628-32, 9415, 8891, & 8760 for our study while these were passing through the central meridian. Each data set consists of a time series of images obtained with the MDI instrument in full-disk mode (spatial scale of ~ 2 arc-sec per pixel), taken with a cadence of 1 minute spanning 2-3 hour intervals.The once a minute images were corrected for the mean solar rotation and then registered with the first image of the observation time, for each data. A two-point backward difference filter was applied to the images to extract the oscillatory part of the magnetogram signals. The rms of the fluctuations of the magnetic fields is calculated using the consecutive residual magnetograms separated by 1 minute. Figure 1 shows the mean magnetogram overlaid with the contour maps of the rms values of the fluctuations of the magnetic field for the active region. It is seen that the rms fluctuations are enhanced significantly above the mean variability at a few locations within the active regions, generally in strong field regions.

3. Discussion and Conclusions

The magnetic fluctuations seen in MDI magnetograms amount to a dynamical pressure fluctuation of about $B.\Delta B/4\pi$, which is about 6000 dynes cm^{-2}, for B = 1500G and ΔB = 50G. This is much larger than the dynamical pressure of the typical five minute oscillations ρv^2, which amounts to about 100 dynes cm^{-2} for $\rho = 10^{-7}$ gm cm^{-3} and v = 300 m s^{-1}. These numbers show that the magnetic fluctuations can drive velocity oscillations and not vice versa. Since the five-minute oscillations are generally known to be suppressed in regions of strong magnetic field, the reported enhanced power at higher frequencies requires a different driver from the convective motions that are now regarded as the drivers of the quiet sun five minute oscillations. The observed enhanced magnetic power at higher frequencies could provide the driver.

The total equivalent mechanical flux P, corresponding to the dynamical pressure fluctuations can be given by $P = \frac{B.\Delta B.V_A}{4\pi}$. Borrowing the earlier estimate of 6000 dynes cm^{-2} for the equivalent pressure fluctuations, and about 10 km s^{-1} for the value of the Alfven speed V_A at the photosphere, we arrive at a value of $\sim 6\times10^9$ ergs cm^{-2} s^{-1} for P. We may expect only a fraction of this flux to actually be available for heating the chromosphere/corona. Given that the flux actually required to heat the active region chromosphere and corona are $\approx 10^6$ ergs cm^{-2} s^{-1} and $\approx 10^5$ ergs cm^{-2} s^{-1} respectively (Withbroe & Noyes 1977), we see that only 0.1% and 0.01% of the estimated flux is needed for this purpose. The magnetic fluctuations reported here, thus provide a natural source for high frequency acoustic waves that can heat the active region chromospheres, besides providing a natural explanation for enhanced high frequency acoustic power in magnetized regions of the solar photosphere.

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