OSCILLATIONS IN SUNSPOT UMBRA, -PENUMBRA AND THE SURROUNDING PHOTOSPHERE

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ABSTRACT. Doppler shifts of the nonsplit line Fe I 7090Å have been measured simultaneously in the sunspot umbra, penumbra and the photosphere using a 100 x 100 diode array. The power in the range 2.5 - 4.5 mHz is found to decrease from the photosphere towards the umbra. Besides the minimum at the center of the umbra, further power minima occur at the transition region between umbra and penumbra. No significant power is found in the range 5.0 - 6.0 mHz.

1. OBSERVATION AND REDUCTIONS

A type H sunspot was observed on April 24, 1984 from 11 : 50 through 14 : 10 UT at the Locarno solar station of the Göttingen observatory (Wiehr et al., 1980) at 1° W, 14° S corresponding to a heliocentric angle of 9.°2. A 100 x 100 diode array controlled by a microprocessor (Küveler and Wöhl, 1983) was used which is particularly sensitive at the near infrared region of the Fe I 7090.3 line (g=0). The total exposure time for a single measurement was 11 s, successive measurements were done every 33.8 s; 248 frames covered the total observation period.

After subtraction of the dark current and division by the flatfield, the spectrograph drift was corrected by positions of a telluric H_2O line at 7027Å measured simultaneously with an additional linear 128 diode array (Küveler and Wiehr, 1985). Velocity shifts due to the Earth's motion were subtracted. Two successive array rows (ΔX = 0.5 arcsec) were averaged in order to diminish the noise level, the spatial resolution anyway beeing not larger than 1 arcsec. The 248 individual frames were displaced in such a way that the umbral minimum intensity always occurs at the same frame row. This removes guiding errors in the

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direction of the slit. By this procedure some rows are lost in addition to those which had to be skipped because of array defects. The final 36 rows are shown in Figure 1.

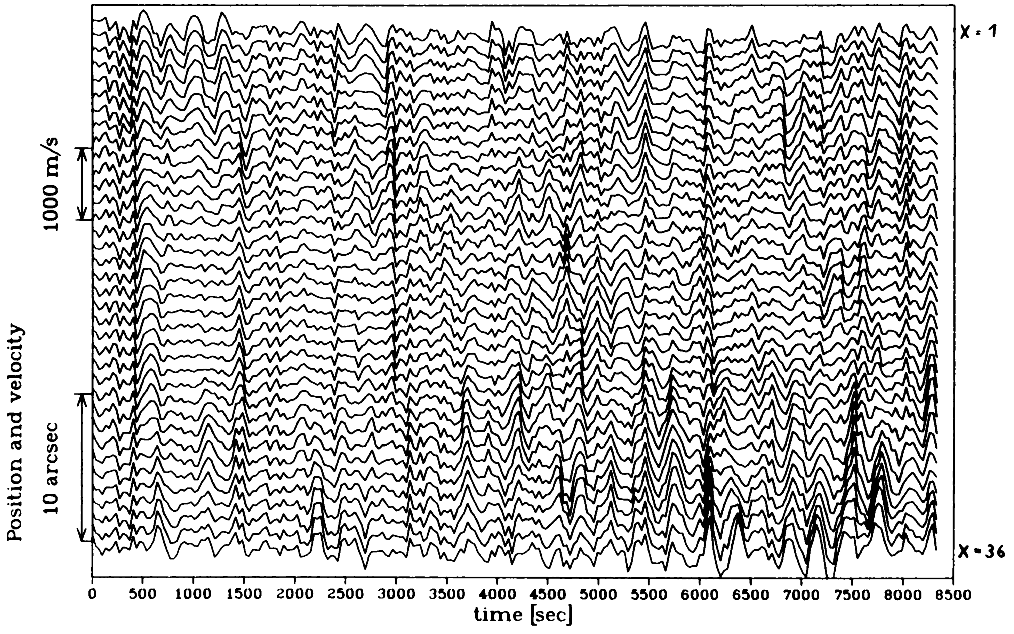

Figure 1. The velocity data.

2. RESULTS

In the sunspot, the power in the range 2.5 - 4.5 mHz is much less than in the photosphere, but it is still existing. The power integral in the umbra amounts to 26% of that of the photosphere, in agreement with Thomas et al. (1986).

The power does not decrease monotonically; instead minima are found at the center of the umbra and at the transition between umbra and penumbra, separated by local maxima (s. Figure 2). The detailed structure of the power spectra changes within a few arcseconds (Figure 3). No significant power is found in the range 5 - 6 mHz, in agreement with the former work of Balthasar and Wiehr (1984), but in contradiction to the results of Lites (1986).

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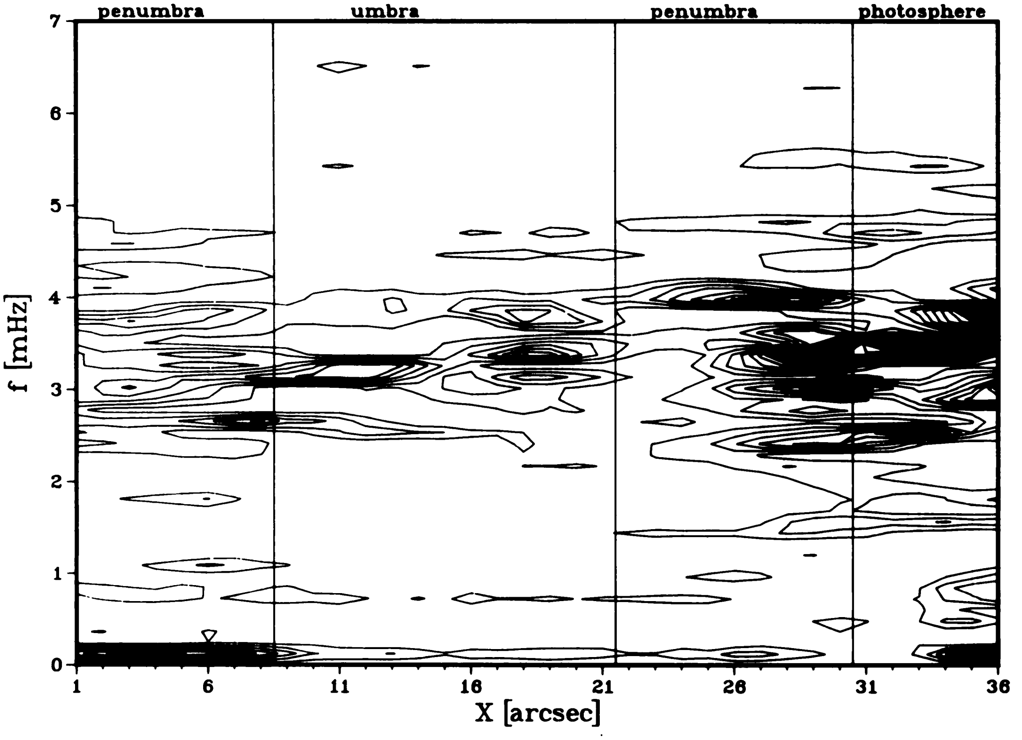
3. DISCUSSION

According to Groth (1975), a power peak ten times above the noise is produced by a signal exceeding the noise amplitude with a probability of more than 99%. The noise level estimated from the range 9.9 - 14.8 mHz (last third of the range below the Nyquist frequency) is about 50 $m^2 s^{-2}$. Thus, most of the power peaks in the range 2.5 - 4.5 mHz cannot be produced by noise.



Spot April 24, 1984, Distance of contours: 250 [m/sec]**2

Figure 2. Dependence of the power on position X and frequency f

The non-monotonic decrease and the spatial variation of the power pattern are hints that the power cannot originate exclusively from parasitic light - in agreement with the former finding of oscillations using the Stokes-V-inversion point, e.g. by Balthasar and Wiehr (1984).

The absence of power in the the range 5 - 6 mHz could

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perhaps be explained by the depth in which the Fe I 7090 line is formed. Those lines used by Lites (1986) or by Thomas et al. (1986) are formed in higher layers, where the influence of the chromospheric oscillations might become stronger.

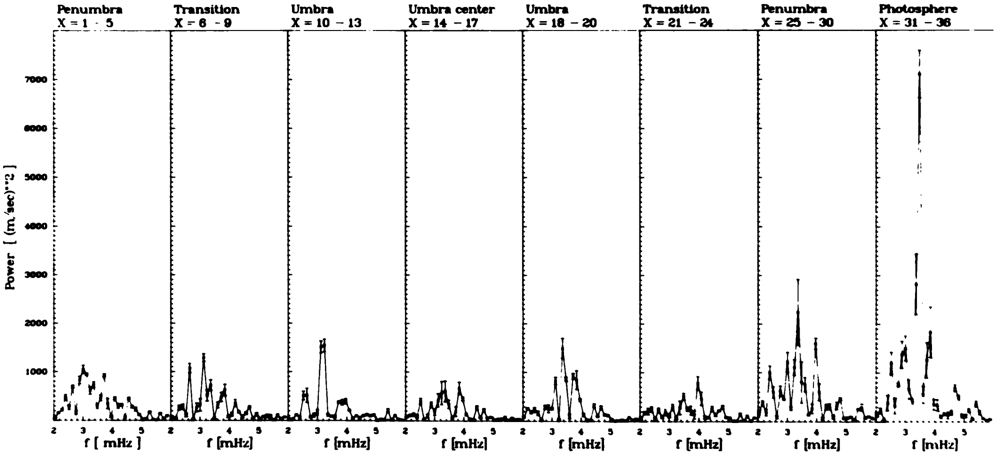

Figure 3. Averaged power over regions showing similar behaviour in Figure 2. The bars represent the errors of the mean values.

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