OSCILLATORY PROPERTIES OF MESO-SCALE INTENSITY STRUCTURES AT CHROMOSPHERIC LEVEL

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ABSTRACT. We show the evidence at chromospheric level (CaII K line) of meso-structures, "mesocells", reminiscent of the mesogranulation by their spatial size (8 Mm). These cells present very regular oscillations in intensity, preferably in the 3-5 min. period range, and we show that the phase of the sustaining wave extends smoothly (coherently) over the mesocell area.

1. INTRODUCTION

A recent dynamical analysis (Damé, 1985) of variations of solar intensities in the CaII K line has raised the question of whether or not observed cellular patterns whose spatial scale is in between the granulation and supergranulation sizes could be of oscillatory nature.

Several morphological studies in the high photosphere and transition region have clearly shown the presence, in velocity as well as in intensity, of cells of 7 to 8 Mm spatial size. Independantly, excellent white light observations of granulation (Kawaguchi, 1980, Oda, 1984) show that active granules which possess a repeated fragmentation and merging of 5.7 min. period are arranged in meso-cells of 8.1 Mm and tend to expand almost simultaneously.

To better understand the meso-cells behavior we study a longer time sequence (50 min.) of CaII K line filtergrams with a time resolution of 10 s and an excellent spatial quality (sub-arcsec resolution). These high spatial and temporal resolutions which preserve the full dynamic and amplitude of the oscillations in the line allow to determine the true contribution of the 3-5 min. oscillation in the meso-cells intensity fluctuations.

2. SPATIAL FREQUENCIES

The CaII K line filtergrams (1.2 Å bandpass, line centered) are presented (observations and data reduction) in Damé et al. (1984).

We applied a 2D Fast Fourier Transform (FFT) on suitably apodized individual filtergrams and on their average. The resulting spectra indicate that a clear resolved

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structure of 8 Mm exists in individual filtergrams. However, on the average of the time sequence, this dimension is totally absent.

This 8 Mm dimension is comparable to the "mesogranulation" dimension observed by November et al. (1981) in the high photosphere, and on individual filtergrams of the temperature minimum region (160 nm) obtained durind rocket flight experiments by Foing and Bonnet (1984).

Those *mesocells* are not a permanent stable structure in emission. They are *instantaneously* present but possess a temporal evolution which prevents their observation on a long term average.

3. TIME EVOLUTION OF THE MESOCELLS

The topology of the mesocells in individual filtergrams is evidenced through a selective spatial filtering of 4 Mm bandwidth peaked at 8 Mm. On a selected filtered image (figure 1) we can observe that the mesocells distribution is very regular and that specific bright mesocells do not necessarily correspond to network elements. They are uniformly distributed. The darkening aspect of the borders is simply due to apodization. Filtering is done in the Fourier domain. The larger dimensions of the top and right bands are due to added zeros for dimensioning purposes of the FFT algorithm.

One could note that many of the mesocells would have totally changed of intensity in 3 minutes of time. However, if all cells do present a change, some of the cells may either be brighter or darker in average. More quantitatively we followed the time evolution of the intensity of selected mesocells, dark or bright, on 12 minutes.

Averages of the intensities over two selected areas are represented in function of time (figure 2). The area of averaging is10 X 10 arcsec. An important 3 min. oscillation is clearly evident, and its amplitude represents around 50 % of the mean value of the filtered cell (20 to 30 % of the unfiltered mean).

Cells of nearby areas (in supergranular cells) often present in phase brightning or fading. Note that the "quiet" background level often progressively increases or decreases over the 12 min. time base. This may suggest that the mesocells are not absolutly spatially stable (slow change of mean spatial position). Another possibility would be a progressive increase of stocked potential energy that could be released later (this is frequent in the case of CaII K line "bright points" : 1 over 3 or 4 brightnings is often observed to be stronger, cf. Cram and Damé, 1983).

4. WAVE ANALYSIS

The complete sequence (50 min.) of 2D filtergrams is Fourier transformed in order to search for periodic motions at several frequencies (chooseen to be submultiple of the sequence duration). In other words, each pixel (x_{ij}) of the image (2D field) is replaced, first, by the amplitude of its power spectrum (which gives what we call *intensity maps*) :

$$I_{ij} = \sqrt{a_{ij}^2 + b_{ij}^2}$$

where $a_{ij} = \sum_n x_{ij} \sin \frac{2\pi\Delta t}{Tm} . Ap(n)$ with n : number of images

Ap (n) : temporal apodization function

$Tm = T/_m$ T : sequence duration

$$b_{ij} = \sum_n x_{ij} \cos \frac{2\pi\Delta t}{Tm} . Ap(n)$$

m = 3, 22

(20 frequencies : $\omega = 2\pi/_{Tm}$)

For informations on the propagation properties of the involved waves and on the *coherence* of the oscillatory phenomenon (in-phase brightnings) we also established maps of the phase for the selected frequencies. In this case I_{ij} is replaced by :

$$\Phi_{ij} = \mathrm{Arg}\,(a_{ij} + i\, b_{ij})$$

Φ varying from $-\pi$ to π (without redondancy since the individual frequency bands are elementary frequencies).

A phase map is displayed for the period 200 s (figure 3). Intensity maps, illustrating the dissipated power or emmission, are really contrasted, most of the energy (oscillatory energy) beeing concentrated into small points (cf. Damé et al., 1984). The phase maps, on the contrary, show smooth, extended structures indicating that the phase is conserved in nearby points, and well correlated on finite areas (area of coherence of the wavefront).

To characterize the dimensions of the patterns, a 2D spatial Fourier Transform is applied to the phase and intensity maps (the 2D resulting transform beeing circularly projected on a single axis, assuming no particular symetry, which is allowed according to the aspect of the 2D preceding maps).

The individual spectra obtained for each single resolved frequency (both in intensity and in phase) are averaged 5 by 5 in order to lower the residual noise. This resume the analysis to 4 frequency bands respectively centered at 150, 200, 300, and 600 s (the equivalent bandpass is 16 mHz).

Both the dominant charasteristic sizes of the recurrent dissipation (intensity information) and the most probable sizes of the lateral coherent extent of the driving wave (phase information) show the considerable influence of the 8 Mm dimension. The 8 Mm is an important size for dissipation (intensity maps) except near 200 s where a large part of the energy goes into finer structures. The *coherent* extent of the wavefronts evidenced by the phase cells dimension (phase maps) is 7 to 9 Mm with a good confidence level in the 150-300 s range of periods. For longer periods a rapid decrease of the coherence is observed.

5. CONCLUSIONS

The analysis of individual CaII K line filtergrams clearly revealed the existence of meso-structures, "mesocells", in the chromosphere. The mesocell is not, however, a permanent stable emissive structure, its presence beeing not observed on the time average of the filtergrams.

A possible influence of the 3-5 min oscillation in the mesocell origine and time evolution is consistent with the results of the temporal Fourier Transform of the complete sequence. Both in intensity (power) and in phase of the oscillation, a finite spatial dimension of 8 Mm (11 arcsec) is observed. In intensity, this extended structure is partly masked by the important local dissipation of the cells bright points while, when the phase is considered, the extent of the *Phase Cells* is directly comparable with the size of the observed mesocells. The coherence of the phase over the mesocells is an evidence for their oscillatory nature.

Another independant evidence for the oscillatory nature of the phenomenon is the sine like periodic brightnings of selected filtered mesocells. The large amplitude and regularity of the phenomenon suggest a stable stationnary wave source origin (higher spatial harmonics of the primary supergranular cell), rather than the convection directly (cellular motion).

The fact that the emission (intensity incease) takes place in a smaller region than the area over which the phase is coherent implies that another phenomenon induces the dissipation. This could suggest interaction of incoming wavefronts with localized magnetic flux tubes.

Our next concern is to compare the time evolution of bright points and mesocells intensity fluctuations using intensity calibrated filtergrams. A comparison with simultaneous spectroheliograms could also be used to clarify the nature of the involved wave.

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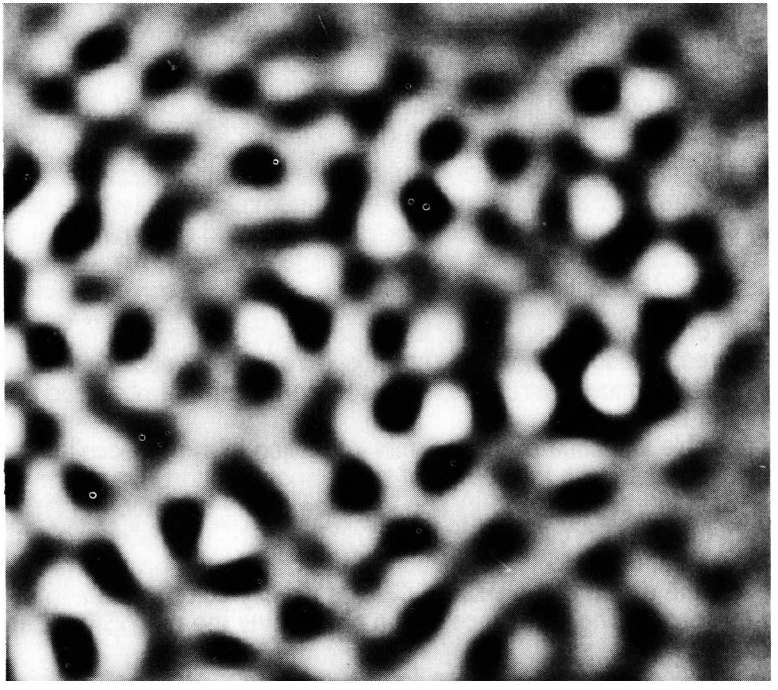

Figure 1. Individual filtergram of the CaII K line filtered through a selective spatial filter of 4 Mm bandwidth centered at 8 Mm. The field area is 2 X 2 arcmin.

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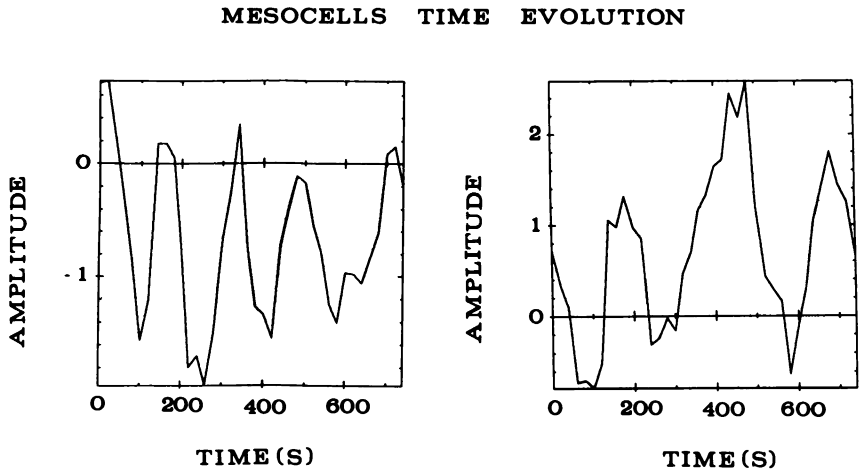

Figure 2. Time evolution (12 min. basis) of the average intensity of selected mesocells (10X10 arcsec size). The zero line indicates the average value of the average filtergram.

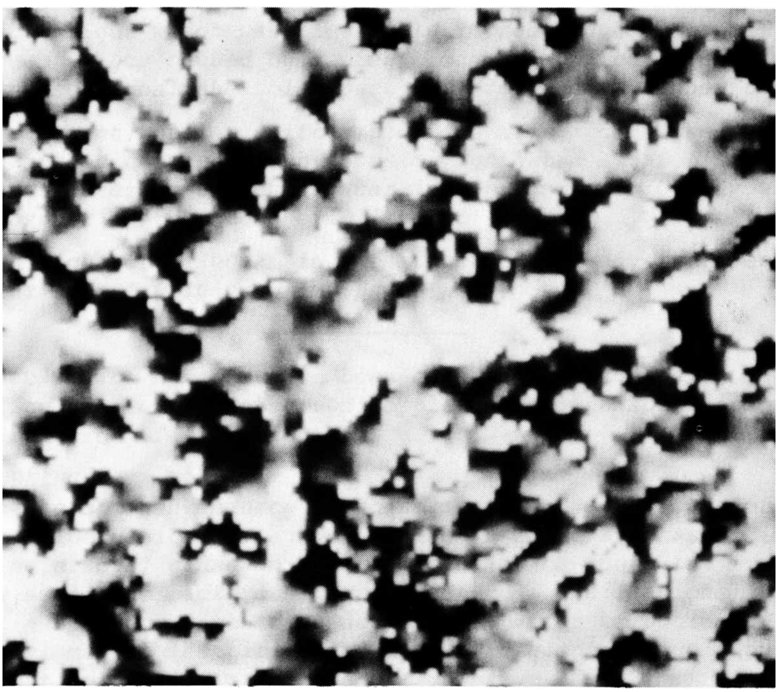

Figure 3. Phase $(-\pi,\pi)$ of the temporal Fourier Transform of the 2D sequence of filtergrams (Period 200 s). The average size of *Phase Cells* is 8 Mm.

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