Mem. S.A.It. Vol. 76, 973

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High resolution observations of chromospheric network

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Abstract. There is an increasing evidence that primary driver of solar variability, on time scales of days up to the solar activity cycle length, is the evolution of magnetic field present on the solar surface. In this paper we investigate the correlation between the photospheric structures and emerging magnetic elements by means of high spectral resolution images containing network cells. We present the preliminary results derived from the analysis of observations carried out in the spectral lines Ca II 854.3 nm, Fe I 709.0 nm and Fe II 722.4 nm with the 2-D Interferometric Bidimensional Spectrometer IBIS installed at the DST - Dunn Solar Telescope, Sacramento Peak (NM).

1. Introduction

Solar surface shows a wide variety of magnetic structures, ranging from the largest sunspots (tens of Mm across) down to the 100 km scale magnetic elements, the smallest observable forms of magnetic flux in the photosphere. The arrangement and evolution of magnetic elements emerging on the solar surface are strongly influenced by the spatial and temporal behaviour of photospheric convective flows. In quiet areas magnetic field concentrations appear as single bright points, whose dynamics is determined by granular flows. These bright points are passively advected towards the borders of supergranular cells, where they gather and produce the magnetic network, a useful proxy for supergranules. This network is considered a key component for solar radiance reconstruction and energy transport towards the upper solar atmosphere. In order to investigate the interaction between the photospheric velocity field and emerging magnetic elements, observations with high spectral and temporal resolution and with a spatial scale of about 100 km on the solar surface are necessary.

We present a 3-D reconstruction of the photospheric velocity field of a quiet region centered on a large scale (~ 30 Mm) structure of magnetic network and an analysis of the photospheric plasma dynamical properties below a cluster of magnetic structures.

2. Observations and data analysis

The data set contains observations of a roundish network cell collected by the IBIS 2-D spectrometer on October, 16 2003 (from 14:24 UT to 17:32 UT) in the spectral lines Ca II 854.2 nm, Fe I 709.0 nm and Fe II 722.4 nm. The temporal interval between successive images was ~ 300 ms. Each monochromatic image was acquired with 25 ms expo-

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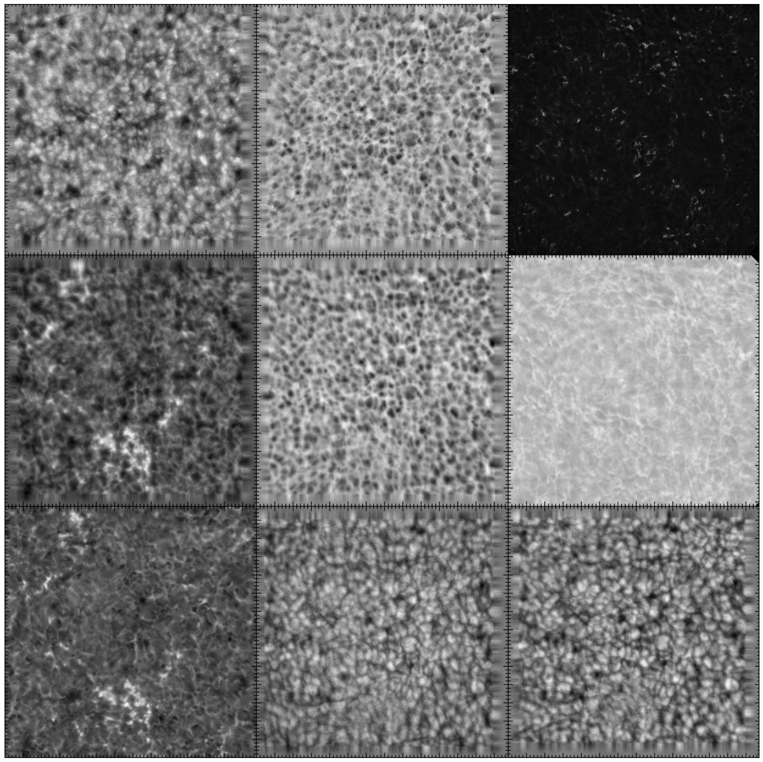

Fig. 1. Upper left panel: Fe I 722.4 nm line core field; upper central panel: Fe I 722.4 nm Doppler velocity field; upper right panel: Fe II 722.4 nm width field; central left panel: Fe I 709.0 nm line core field; central panel: Fe I 709.0 nm Doppler velocity field; central right panel: Fe II 709.0 nm width field; lower left panel: Ca II wing intensity image; lower central panel: Fe I 709.0 nm continuum image; lower right panel: Fe II 722.4 nm continuum image. Minor ticks correspond to 1", major ticks to 5".

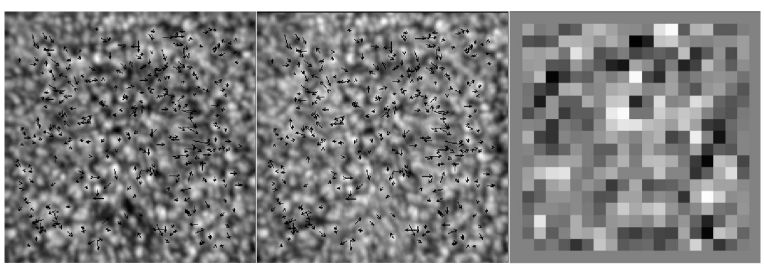

Fig. 2. Average continuum (left panel) and Doppler velocity (central panel) images with superimposed the tracked granule displacements represented as black arrows. The granules were tracked by applying the TST to the first half hour of each time series; right panel: mean divergence image extracted from the horizontal velocity field.

sure time by a CCD detector, whose pixel scale was 0.17"pixel^{-1}. Each image was corrected for CCD non linearity effects, dark current, gain table and blue shift (Reardon et al. 2003). The vertical velocity fields were computed for the Fe I and Fe II lines by means of a Doppler shift evaluated, pixel by pixel, using a Gaussian fit of the line profile. The line

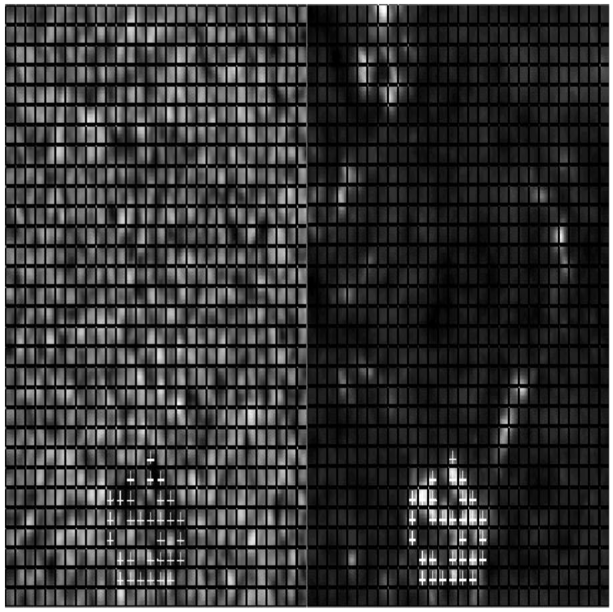

Fig. 3. Mean Doppler and Ca II images averaged over ~ 1 hour. The rebinned pixels are shown as a superimposed grid. The crosses mark the selected magnetic region.

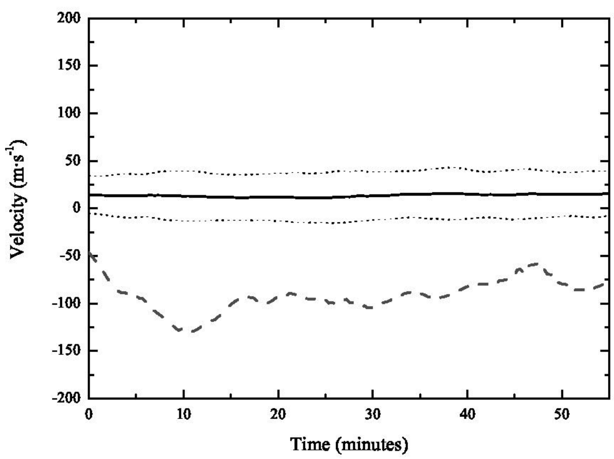

Fig. 4. Average Doppler velocity in the magnetic pixels vs time (grey dash-dotted line). Average Doppler velocity in the reference ensemble (black continuuous line) and average Doppler velocity ±1 standard deviation (black dotted line).

core and width fields were obtained by the amplitude and width, respectively, of the same Gaussian function. We apply the TST procedure (Del Moro 2004) on the continuum image series and on both the Fe II 722.4 nm and Fe I 709.0 nm velocity field series in order to retrieve the horizontal velocity field at different depths of the solar atmosphere. In fact, the major contribution to these Doppler fields comes from the two layers at about 140 km and 70 km above the photospheric surface, for the 722.4 nm and 709.0 nm lines respectively. For each time series the TST produced two horizontal velocity fields, associated with the first and second 30 minutes of the series. In Fig. 2 the outputs of the TST are presented. The arrows representing the tracked granules displacements seem to gather on the borders of the supergranule, with the notable exception of the extended cluster of bright structures in the low part of the field. This behaviour is confirmed by the mean divergence image, extracted from the horizontal velocity field, which shows that the bright magnetic area is not a region of convergence. This seems to suggest that granules on the edge of the supergranule are in some way different from the granules in the centre. In order to study the evolution of the downflows below the bright cluster on the low part of the field, we rebinned Ca II and Doppler images to a suitable scale and then calculated the mean Doppler velocity for the pixel forming this cluster, selected from the Ca II images. The rebinned pixels are shown as superimposed grid. The pixels composing the selected magnetic regions are shown with white crosses superimposed on the mean Doppler velocity and Ca II images averaged over ∼ 1 hour. In Fig. 4 the plot of the mean Doppler velocity (grey dash-dotted line) of the cluster pixels against time is reported. The downflows constituting the magnetic cluster have mean Doppler velocity value of ∼ 100 ms^{-1}. In order to evaluate the significance of theis value, a statistical analysis of the distribution of the Doppler mean values of similar clusters has been performed. In particular we compare this value with the Doppler mean values of 250 similar cluster, made up of 32 pixels randomly disposed on a 8×8 sub matrix randomly placed on the image. For each image we calculated the mean Doppler velocity value and its standard deviation on this ensemble (continuous and dotted black lines in Fig. 3, respectively). The average mean Doppler velocity value is $<< V >_s>_t \sim$ 13 ms^{-1} and the average standard deviation value is $<< \delta V >_s>_t \sim$ 15 ms^{-1}.

References

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