SOLAR CONVECTION AND OSCILLATION INTERACTION

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Abstract. In this paper we investigate bisectors of solar photospheric lines. The bisectors reflect vertical velocity gradients over the height of line formation and therefore reveal important information about the dynamics in these layers. Their shape and shift is influenced by (a) convective motions, (b) oscillatory motions that can act differently at different photospheric heights. The bisectors are selected from different locations that show mainly a granular evolution or an intergranular evolution. Two selection criteria were applied: continuum intensity (enhanced for granular bisectors, reduced for intergranular bisectors), and full width at half maximum values (enhanced for intergranular bisectors). The results demonstrate how oscillatory motions influence the bisectors as a whole. In the example given a smaller amplitude of oscillations over intergranular areas is indicated.

Key words: Solar photosphere - high resolution - bisectors - five minute oscillations

1. Introduction

The solar granulation and the associated motions play a key role for the generation of acoustic flux, small scale magnetic element motions and small scale dynamo effects in the solar photosphere that certainly influence the above lying chromosphere. A review about the solar granulation was given by Muller (1999) and the above mentioned interactions were described in more detail e.g. by Stein *et al.* (2007).

The study of the granulation dynamics of the solar photosphere requires 2-D observations, ideally spectroscopic data. Such data were obtained by scans made at the VTT telescope over a small field on the quiet Sun photosphere. From such scans 2-D images of the line parameters were reconstructed and also the corresponding bisectors. Therefore, the variation of

the bisectors as a function of time could be studied. Bisectors half the line profile at equal intensity levels at both the right and left part of the line profile with respect to the line centre. They reflect vertical velocity gradients over the height of line core formation. Time series of solar photospheric line bisectors were studied by Hanslmeier, Bonet and Vazquez (1999). Their data consisted of 1-D spectrograms, taken at intervals of 20s over a total time span of 47 min. The big advantage of our data is their 2-D structure.

2.   Data

Our observations were made at the VTT at the Observatorio del Teide (Schröter, Soltau and Wiehr, 1985). Two photospheric lines were selected:

- line 1: 630.2499 nm, h=270 km

- line 2: 630.1508 nm, h=378 km,

where h denotes the line core formation height. The data analysed consist of six 2-D scans, the size of the field was 12.8×20 arcsec and each scan required 125 s.

The region scanned was near the solar disc centre. By comparison with Ca-II images it was ensured that a non active region was selected. A more detailed description of the data can be found in Hanslmeier *et al.* (2008).

From the line profiles the bisectors were calculated. In order to make a distinction between granular and intergranular bisectors, two criteria were applied: (a) continuum intensity, bisectors coming from enhanced continuum intensity areas of the scan were called "granular bisectors", (b) full width of half maximum, fw; bisectors coming from regions of enhanced fw were called "intergranular bisectors". The time evolution of such granular/intergranular bisectors was then studied.

3.   Results

In Figure 1 the results for "intergranular bisectors" are given. The top panel shows the continuum intensity variations for the six time steps. The area from which the bisectors were selected is marked. The bisectors were defined according to reduced continuum intensity. The six panels represent continuum intensity fluctuations. The spatial region that was selected for bisector
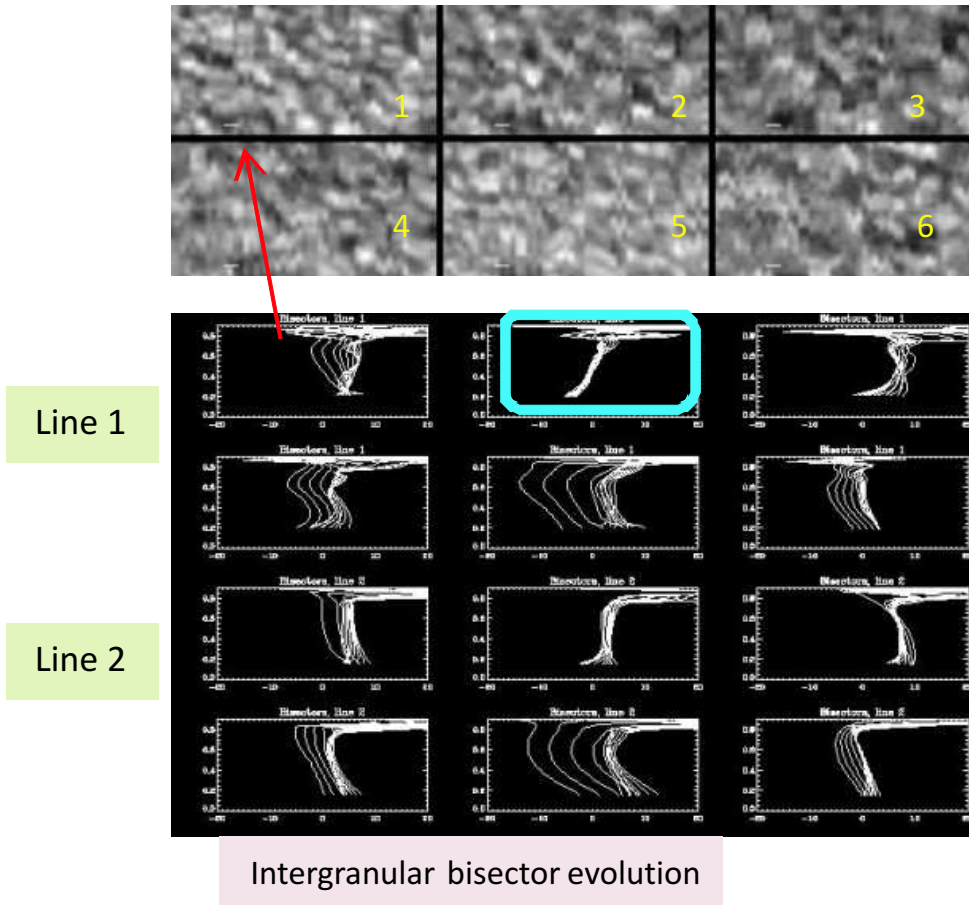
Figure 1: Bisectors selected for reduced continuum intensity. Note that the marked bisectors represent intergranular bisectors shifted to the blue.

evaluation is marked in each of these panels. In many cases, the bisector foot points are shifted to the negative values (blue) however their endpoints are shifted to the red. The first six panels give the bisectors for line 1, the second six panels the bisectors for line 2. One set of bisectors is marked. This shows a case of intergranular bisectors that are shifted to the blue. They are clearly red asymmetric which is to be expected for intergranular bisectors.

In Figure 2 the results for "granular bisectors" are given. Again, in the

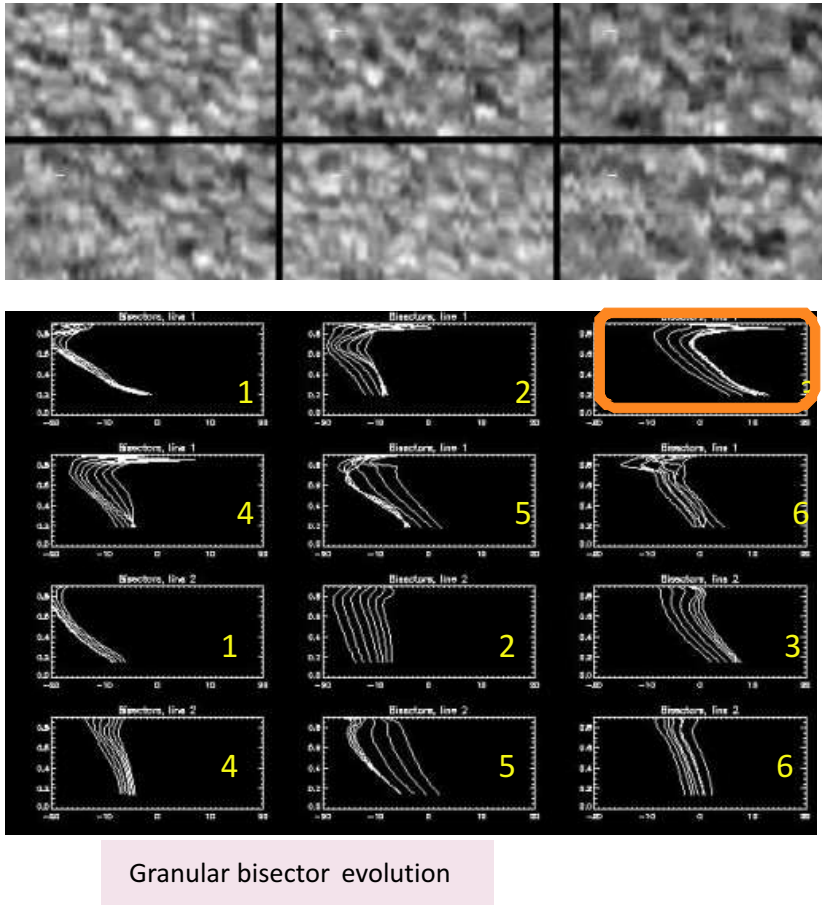*Cent. Eur. Astrophys. Bull.* **33** (2009) 1, 51–57

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Figure 2: Bisectors selected for enhanced continuum intensity. Note that the marked bisectors represent granular bisectors shifted to the red (panel No. 3).

top panel the continuum intensity variation is given and the area from which the bisectors were calculated is marked. The selection criterion was continuum intensity again, in this case enhanced continuum intensity. Again a case is marked where the granular bisectors appear shifted to the red but are blue-asymmetric.

In Figure 3 the results for enhanced fw bisectors are given. In the top panel the variation of the fw values is shown and the area from which the bisectors were selected, is marked. The case marked denotes intergranular
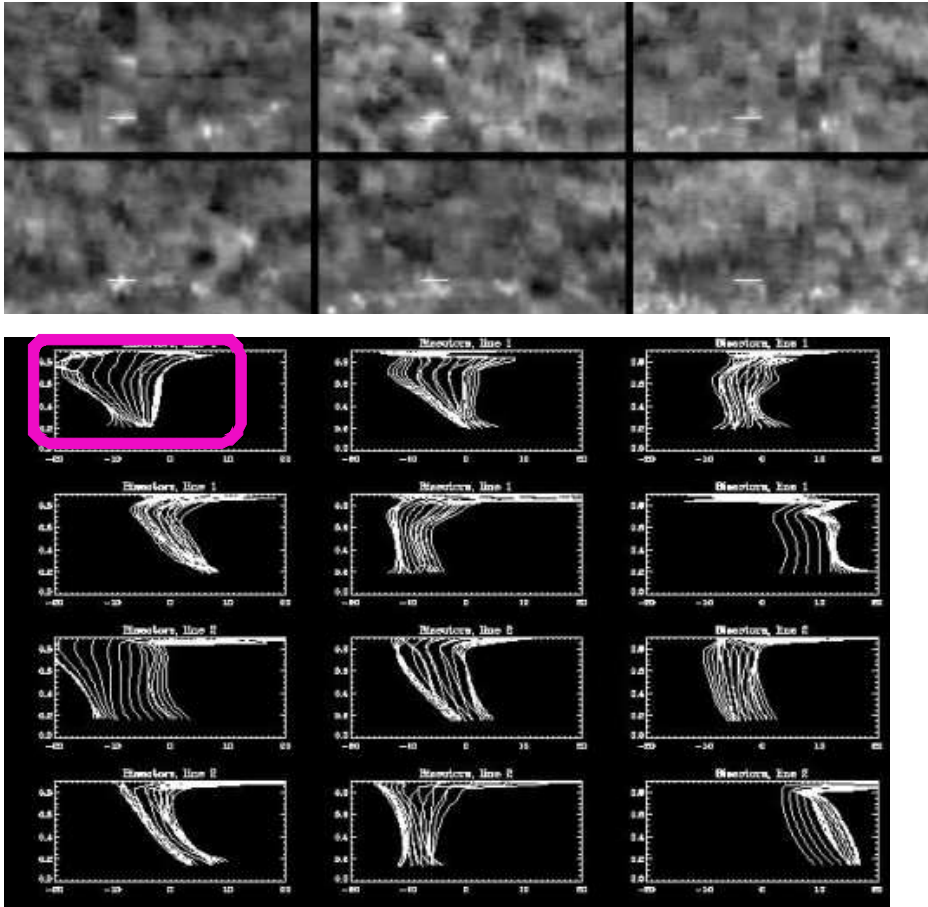
Figure 3: Bisectors selected for enhanced continuum intensity. Note that the marked bisectors represent intergranular bisectors shifted to the blue.

bisectors that appear shifted to the blue.

4. Discussion

From theoretical as well as observational data we would expect the following behaviour of the bisectors: granular bisectors should exhibit mainly blue asymmetry and be shifted toward the blue, intergranular bisectors should be mainly red asymmetric and shifted to the red. As it is indicated by the

three cases in Figures 1, 2 and 3, intergranular bisectors may be shifted as a whole toward the blue and granular bisectors may be shifted as a whole toward the red. Such a shift can be explained by the influence of oscillations. This influence is known to increase with photospheric height. Therefore, it will affect more strongly the bisector foot points (i.e. near the line centre that originates from higher parts in the solar photosphere).

In the paper of Hanslmeier *et al.* (2008), global correlations between line parameters such as continuum intensity, full width at half maximum, line centre velocity fluctuations were discussed. In that paper in Figure 3 histograms showing the distributions of the line parameters for high (dotted) and low continuum intensity (solid) are given. These histograms allow a clear distinction between granular (high continuum intensity) and intergranular (low continuum intensity) values however, there are also cases of ambiguity. These can be explained by the influence of oscillations. Hanslmeier, Bonet and Vazquez (1999) studied a 47 min of bisector evolution and Odert *et al.* (2005) have also investigated the influence of 5 minutes oscillations on solar photospheric layers in quiet regions. The data used there, however were not 2-D time series but only 1-D series. The problem of 1-D data is that due to seeing influences the spectrograph slit not always gets information from exactly the same position on the Sun. Therefore, the data become strongly influenced by these effects. In both papers it was found that oscillations seem to dominate the intensity and velocity fields of the higher atmospheric layers and it was confirmed the fast decay of the granular intensity structure with height. Five-minute oscillations above granules and intergranular lanes were studied by Khomenko, Kostik and Shchukina (2001). They found different amplitudes, phases and periods of the 5-min oscillations above granules and intergranular lanes. The most energetic velocity oscillations occur above granules and lanes with maximum contrast, i.e. above the regions with maximum convective velocities. Comparing Figures 1 with 2 there is an indication for this: the amplitude of the foot point variations seem to be smaller in the case of intergranular bisectors (< 15 mÅ) than in the case of granular bisectors (> 20 mÅ).

For the first time, the variation of bisectors can be followed as a function of time. This is extremely interesting for theoretical studies since bisectors are indicative for vertical velocity gradients.

Acknowledgements

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