DEPENDENCE OF SOLAR LINE BISECTORS ON EQUIVALENT WIDTHS

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Abstract: Spectroscopic highly resolved solar granulation observations lead to intense line asymmetries for rising and sinking elements. In order to average several granules it is better to use equivalent widths than continuum intensities.

I. Introduction

If we observe unresolved solar line bisectors the typical C-shape structure becomes evident. There are two different types of solar models, homogeneous models-leading to symmetric profiles for better spatial resolution and inhomogeneous models which demand strong line asymmetries of the individual rising and sinking elements of solar granulation due to strong velocity gradients. Theoretical inhomogeneous models have been proposed by Voigt (1956), Schröter (1957), Steffen (1987), homogeneous models by Dravins (1982).

In this paper we try to separate the individual bisectors into rising and sinking elements using the corresponding equivalent widths as parameters.

II. Observations

Only a brief description of the observations is given here. 10 spectra each including the 4 iron lines I: λ = 6494.499 Å, II: λ = 6494.994 Å, III: λ = 6495.740 Å, IV: λ = 6494.472 Å, were recorded with the Gregory Coude Telescope at Teneriffe. The dispersion was 5.1 mm/Å and the photographs covered a region of 145" near the disc center showing no Ca-II activity.

We examined 2 spectra. The data were not corrected for oscillations. Terrestrial lines influence the blue wing of line I and the red wing of line III.
Two spectra #1 and #8 were analysed leading to similar results.

III. Results

The aim of our investigations was to examine wether with enhanced spatial resolution the line asymmetries would increase or decrease. In Fig. 1 a region of 1.6" is plotted showing a change of the bisector asymmetries from blueshifted wings for rising elements to redshifted wings for downflowing material.

There is no longer the C-shape structure as for unresolved spectra. We also

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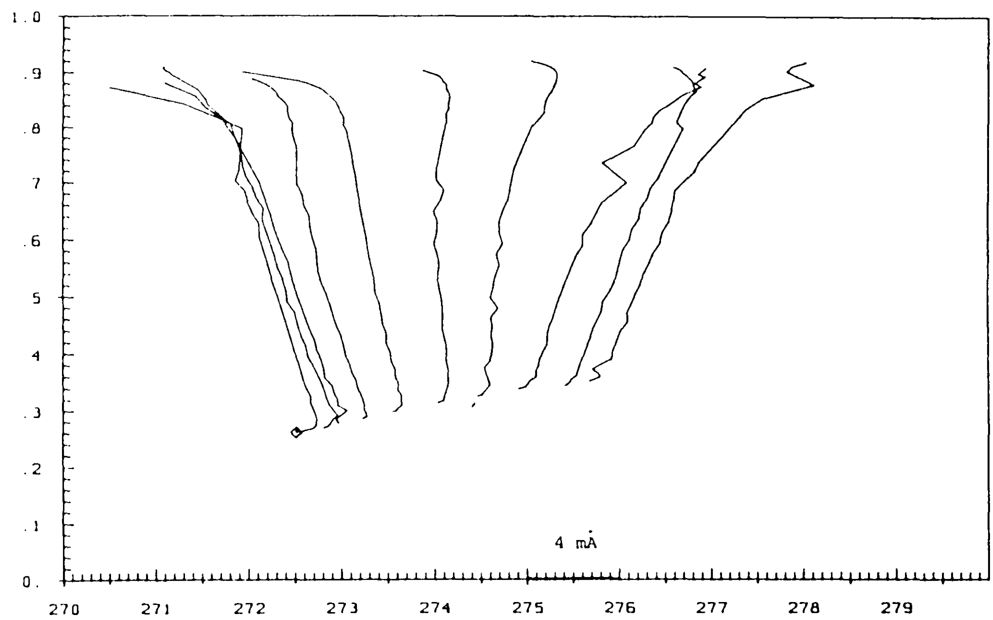

Fig. 1: Plot of 10 individual bisectors of line II
line core redshifted: intergranulum
line core blueshifted: granulum

tried to average similar regions of up- and downflow. This was first attempted by a correlation with the corresponding mean continuum intensities which should vary for bright and dark elements but the correspondence was not unique:
The brightest elements (center of a granulum) do not have the maximum upward velocities. This could be easily explained by radiative cooling processes. Keil and Yackovich (1981) made a correlation of line profiles for up- and downflow and found a decrease of the corresponding equivalent widths for downflows.

Since the spatial resolution of our data was much better this correlation should also be possible. Fig. 2 shows the averaged bisectors for line II according to their equivalent widths. Each bisector is a mean of about 90 individual bisectors. We see a gradual shift of the line core to the red indicating that the left averaged bisectors belong to rising elements and the right bisectors to downflows. A decrease of the blueshift of the line wing is also clearly seen. The asymmetry A varies from -8 mÅ for upflow to -2 mÅ for downflow.

The equivalent widths were defined as

$$eq = \int ((I_{min} - I_{max}) / I_{min})\, dI$$

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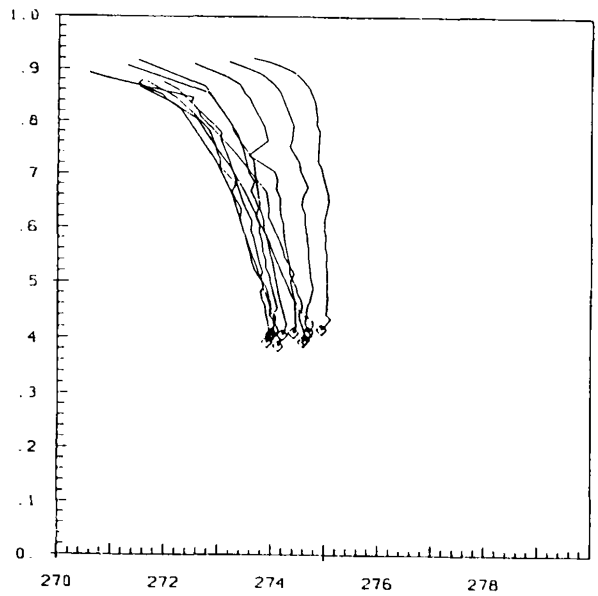

Fig. 2: Averaged bisectors of line II according to corresponding equivalent widths of the line profiles (1 unit = 4mÅ)

Similar results are obtained for line IV as is shown in Fig. 3.

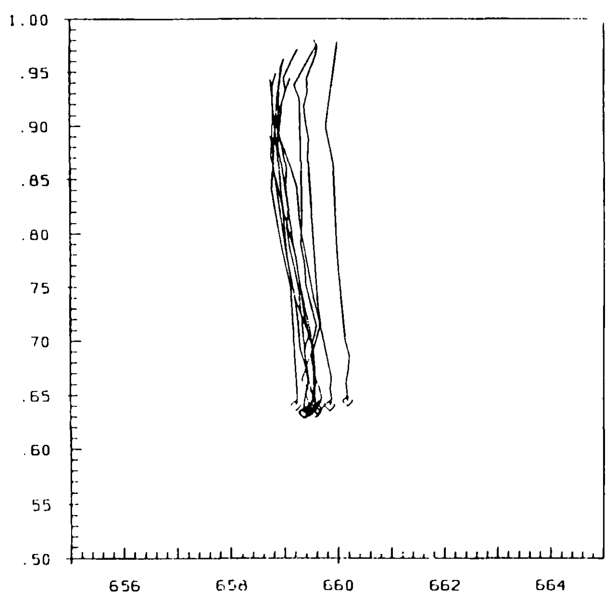

Fig. 3: Averaged bisectors of line IV according to corresponding equivalent widths of the line profiles (1 unit = 4mÅ)

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In this example Λ changes from -1 mÅ to +0.7 mÅ.
One might argue that still these data are of course not fully resolved and that for perfect spatial resolution the observed asymmetries will disappear. Keil and Yackovich (1981) convolved computed line profiles with a seeing function represented by a product of Gaussian functions

$$\exp\ (-x^2\ /\ \sigma^2)$$

were x is the horizontal position within the granulation pattern, σ defines the degree of smearing. They found that regardless of the value of the seeing parameter their observed asymmetries demand steep gradients in the granular velocity field.

Since our data have better resolution this should also be valid here.

IV. Conclusions

In these data a typical granulum consists of about 10 individual bisectors each bisector originating from different parts of a convective cell. In order to determine averaged bisectors one must be careful to use mean continuum intensity fields since bad seeing influences smaller granular structures as numerical investigations of Musmann (1969) showed and radiative cooling processes cause the brightest elements not being the elements of maximum upward velocity. It seems that using equivalent widths is the best suitable parameter for discerning between up- and downflowing elements because the center of line velocities are influenced by oscillations and larger scale motions.

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