BISECTOR AND LINE PARAMETER VARIATION OVER A SINGLE SOLAR GRANULUM

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ABSTRACT We give two examples of bisector and line parameter variations over a single solar granular intergranular area. The variation of these parameters with photospheric height is investigated in detail.

Keywords: Convection; solar granulation; line profiles

INTRODUCTION

The convective overshoot motions in the solar photosphere can be observed as granulation. Because of the small spatial diameter of these elements (about 1 Mm) it is very difficult to study spatially resolved line profiles originating from the hotter ascending granulum and the cooler descending intergranular lanes. These observations are needed for a direct comparison between various theoretical models (Cloutman (1979), Nelson (1978), Nordlund (1982, 1985), Steffen (1989)). The statistical variation of the line parameters over many granular intergranular areas with high spatial resolution has been given by Hanslmeier et al. (1990) and Guenter and Mattig (1990). This paper presents line profiles and line parameter variations from two selected large granular-intergranular areas in a non-active region near the solar disk center.

OBSERVATIONS

The observations have been performed with two different telescopes at the German solar observatory at Izaña, Tenerife: i) Gregory Coudé telescope: 0.45-m; f/56; image scale on the spectrograph entrance slit 8.25 arc-sec/mm and ii) Vacuum Tower Telescope: 0.70-m; f/66; image scale on the spectrograph entrance slit 4.5 arc-sec/mm. In both cases a spectrograph slit width of 60μ has been used. The spectra were obtained photographically with an exposure time of 3 sec.

For a symmetric line profile, the bisectors, halving the line profile at equal intensity levels, are straight lines. Since the line center is formed at higher levels in the solar photosphere, asymmetric line profiles leading to curved bisectors, represent velocity gradients.

We present results from the analysis of the line at 6494.994 Å which had a line core formation height about 500 km. Therefore, nearly the whole photosphere up to the temperature minimum was covered. More results from
observations with the Gregory Coudé telescope can be found in Hanslmeier et al. (1991).

RESULTS

The following examples give the line bisector variation (a), the continuum intensity variation (b) and the full width at half maximum variation (c) over a selected single granular-intergranular area. The data from Fig. 1 are from the Gregory Coudé telescope, the data from Figs. 2 from the VTT. Two neighboring bisectors in Fig. 1 have a spatial separation of 0.16 arc-sec, in Fig. 2 of 0.137 arc-sec (these values arise from the digitizing of the spectrograms).

Fig. 1: Line parameter variation from an intergranular lane (position #1) to the center of a bright granulum (position #15).

The Bisectors have blue (granulum) and red asymmetries (intergranular lane). The greatest red asymmetries about 15 mÅ are found for bisector #1 in Fig. 1a and Fig. 2a. The maximal blue asymmetric bisectors are found in Fig. 2a (bisector #10) reaching nearly the same values of 15 mÅ.

Fig. 2: Line parameter variation from an intergranular lane (position #1) to the center of a bright granulum (position #10).

The examples show a well defined transition of the continuum intensity $I_0$ from lower to higher values (granulum) with a difference of about $0.1I_0$ between

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intergranulum and granulum. The full width at half maximum FWHM values are increased in the intergranulum. However, as is illustrated by Figs. 1c and 2c, this variation is rather complex. In all examples, the difference between granular and intergranular areas is about 4%. Bisector #11 in Fig. 1a and bisector #6 in Fig. 2a have the smallest asymmetry. It can be shown, that these bisectors coincide with the minima found in the variations of the FWHM.

DISCUSSION

The resolution of the larger granulum is better than the resolution of the smaller intergranular lanes. Therefore we get about the same red and blue asymmetries. From the argument of mass conservation the downward velocity gradients should be greater. For spatially resolved line profiles the bisectors no longer have a C shape, but are blue and red asymmetric according to their origination in the granular or intergranular areas. As can be seen from Figs. 1a and 2a, the shape of the bisectors for continuum intensity $I_0 \leq 0.8$ differ from the shape for $I_0 \gt 0.8$. Since the contribution to the line profile near the continuum value occurs from the deepest photospheric levels, a greater turbulence at these layers cause these variations. The bisectors of Fig. 1a are asymmetric at even higher photospheric levels with lower continuum intensity values. In this example, the convective motions may have penetrated nearly the whole photosphere. The selected area given by Fig. 2a shows no velocity fluctuations at greater photospheric heights, but again strong velocity fluctuations and asymmetry variations in the deeper layers. The analysis of the corresponding continuum intensity variations and full width at half maximum variations show, that on the one hand well known facts are confirmed (enhanced FWHM in the intergranulum which is darker), but that the transitions from granulum to intergranulum is not linear. The point with the smallest line asymmetry seems to be connected with a minimum found in the FWHM curve. The increased FWHM values in the intergranular areas can be explained by non-thermal line broadening in these regions, caused by pressure waves. The asymmetric transition from granular to intergranular lanes is also studied in Nesis et al. (1991a,b).

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Solar Bisector Variation