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DOPPLER MOTIONS IN ACTIVE REGIONS AND IN THE SURROUNDING PHOTOSPHERE

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ABSTRACT We present the preliminary results of photoelectric measurements of line-of-sight motions in the quiet and active photosphere. We show the topology, amplitudes and signs of Doppler motion distribution in active regions and their surroundings. We pinpoint the different characters of both topologies.

INTRODUCTION

Recently, we utilized the results of measurements obtained with our rebuilt photoelectric Magnetograph II. (Klvana, Bumba, 1992), mainly for evaluating line-of-sight velocities.

We measured in the line wings (Fe I 5253,5 A) only, but with a high spectral dispersion of about 5 mm/A, and integrated over an area greater than $(10")^2$. Nevertheless, the sense of motion obtained in active regions is the same as in some other methods (see, for example, Alissandrakis et al. 1991). For our Doppler motion studies we used the line split in the magnetic field. The series of measurements of the same region made in several different lines (strongly and weakly split, and with no splitting at all: $g = 0$) demonstrated that the splitting did not affect the velocity records.

In evaluating our Doppler velocity measurements we eliminated the effect of the differential rotation and determined the mean velocity for the whole region. We then used this velocity to deduce the local velocity amplitudes. Since this mean value may be affected by the predominance of large velocity patterns of one direction, we constructed histograms of all obtained velocity data. They usually displayed a normal Gaussian distribution, especially in the quiet photosphere near the disk center. But they may be strongly asymmetric, for example, in active regions. By estimating the axis of symmetry of the histograms we can correct the mean velocity value.

DISTRIBUTION OF THE LINE-OF-SIGHT MOTIONS ON THE SUN

Our results are based on relatively extensive observational material obtained during the recent three years. Our data represent hundreds of sets of simultaneous photoelectric measurements of continuum (or line center and wings) intensities, the longitudinal component of the magnetic field, and the Doppler velocity distribution in active regions and their quiet surroundings.

The first line-of-sight velocity distribution maps already demonstrated the main behavior of the distribution of photospheric motions, measured photoelectrically: in active regions with large sunspots the prevailing features of these maps represent regular patterns of the Evershed effect with their dependence on the direction toward the solar disk center. Generally, the areas covered by magnetic fields display negative (from the observer) motions. In the case and place of fast magnetic field and sunspot evolutionary changes their patterns are disturbed by positive velocity peaks or pairs of motions of both directions, practically of opposite orientation, if compared with the velocity distribution in the Evershed effect.

We have also found an interesting distribution of the line-of-sight motions in the quiet photosphere without magnetic fields around the active regions.

In this note we discuss the distribution of Doppler motions in not very active regions and in their non-magnetic surroundings only.

1. Line of-sight-motions in the quiet photosphere

For this study we used several sets of measurements made outside the active regions, in sufficiently large areas surrounding them, but not occupied by magnetic fields, not far from the center of the disk ($\geq$ 30°). We chose sets of measurements which were repeated several times during one day or two consecutive days, to monitor the development of the observed patterns in time. All maps used had a resolution of about 5" x 3".

In this case, the amplitudes of the values in the histogram of all measured velocities do not exceed $\pm$(300 – 350) m/sec. The main morphological characteristic of the motion distribution in our velocity maps is the prevalence of areas of positive motions (toward the observer) and their concentration into larger features, while the negative motions (away from the observer) are spread more into smaller, island-like regions. Moreover, the positive motions often seem to be organized into cellular features, resembling the supergranulation in form, size and the dynamics of development: one motion element may be successively transformed into another.

The fact that they do not disappear, but on the contrary, that they strengthen, if we integrate several individual maps obtained during an interval of several hours, is evidence of the reality and stability of these positive motion features.

The five-minute oscillations may change the form of the individual motion distribution patterns substantially, and the sense of motion may also be reversed during these five minutes, but the individual characteristic features can be recognized during most of the oscillation period. The cellular-like structures show a considerable tendency to reoccur, and the places where they develop seem to last at least several days.

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If we record Doppler motions further from the disk center ($\geq 40^o$), the individual motion structures of both senses extend in directions perpendicular to the solar disk diameter.

2. Line-of-sight Motions in Active Regions

Most of our velocity maps demonstrate negative motions in areas occupied by magnetic fields. Their amplitudes are several times greater than in quiet regions. Further from the disk center they may reach values of about 1500-2000 m/sec. Moreover, like the positive motions in the quiet photosphere, the negative motions in magnetic regions are organized into cellular or quasicellular structures. Even the influence of the five-minute oscillations does not disturb these regular features as strongly as in quiet regions.

In regions with large sunspots and large Evershed effect patterns, the presence of cellular negative motion structures is obscured by the negative motions of the effect, although these motions represent their natural part, in the same way as the positive areas of Evershed motions are closely connected with the positive motion features in the spot surroundings.

DISCUSSION OF RESULTS

The presented results are very preliminary.

The histograms of the line-of-sight velocity values in the non-magnetic photosphere not far from the disk center always show that the studied motions, or at least their components of both directions perpendicular to the solar surface, are practically balanced as regards their values and numbers. However, the distribution of morphological patterns of both motion directions does not seem to be balanced: the positive motion areas are more concentrated, forming more often cellular-like structures; the negative motions are broken down into smaller islands, forming regular structures only very rarely. The observed cellular-shaped positive structures, the dynamics of their development and given their tendency to reoccur in nearly the same places over time intervals of many hours, seem to be real physical entities. We have the impression of large bubbles emanating from a relatively stable source in the lower layers of the photosphere.

In active regions the negative motions form cellular features with velocity amplitudes often several times larger than in the quiet photosphere. The positive motion areas can only be seen there in two cases: as a part of an Evershed effect, or during times and in places where the magnetic field and spots change and develop (during growths and decays). The positive motion peaks then interact with the negative motion maxima (Bumba et al. 1993). The active region's negative motion patterns are surrounded by extended fields of the positive motion features and negative motion islands. We have not learned yet how they are mutually related and what is the real distribution of the motion vectors. We have also to investigate how the Stokes V signal contaminates our Doppler measurements in active regions.

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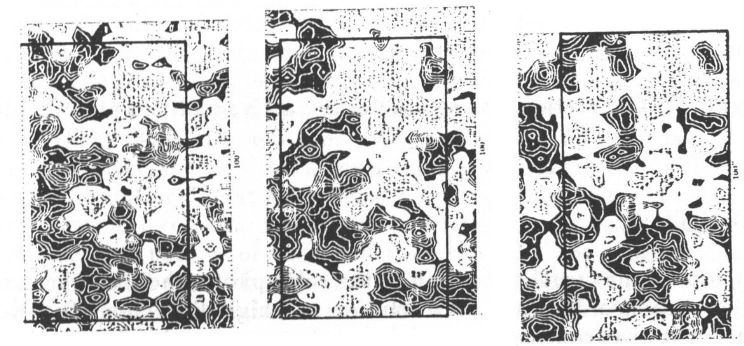

Fig. Three maps of Doppler motions distribution in a quiet photosphere taken with a time difference of about 1 hour. Dark areas represent positive motions.

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