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LINE-OF-SIGHT AND PROPER MOTIONS IN THE FLARING JUNE 1991 (NOAA 6659) ACTIVE REGION

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ABSTRACT We present the results of comparison of photoelectrically and photographically made measurements of Doppler and proper motions with the distribution of the longitudinal magnetic field and spot topology in this large complex region.

INTRODUCTION

During four days of observations in July 1991 with our new photoelectric Magnetograph II at Ondřejov (Klvaňa, Bumba, 1992) we succeeded in getting 13 full and 2 partial sets of maps (continuum and line intensities, longitudinal magnetic field and line-of-sight velocity) of the large active region NOAA 6659, which had just disintegrated on the disk and, at the same time, produced relatively large flares, five of them visible in white light.

Due to the rapidly changing morphology of its sunspot group, we were also interested in the distribution of the individual spot umbrae and in their proper motions, as they were photographed and measured in the Debrecen Heliophysical Observatory.

In this short note we would like to compare the line-of-sight and proper motions occurring in the group, and to demonstrate their relations to spot group morphology, to its magnetic field topology, and to their changes.

CHANGES IN SPOT GROUP MORPHOLOGY AND MAGNETIC FIELD TOPOLOGY

The disintegration of a few large umbral nuclei into smaller ones, accompanied by the formation of bright photosphere-type light bridges, and the disappearance of a large part of the penumbral fields were the main characteristics of the spot group decay. Its magnetic field was negative in most umbrae.

The magnetically positive, larger, relatively stable umbra in the northern part of the group was separated from the rest of the opposite polarity nuclei by a penumbral type (penumbral fibrils elongated along the magnetic field boundary) light bridge. There were still two or three smaller positive polarity concentrations at the outskirts of the main negative field body whose magnetic flux was changing.

LINE-OF-SIGHT MOTIONS IN THE GROUP

As discussed elswhere (Bumba, Klvaňa, 1992), the whole area occupied by the region's magnetic field displayed negative (away from the observer) line-of-sight motions, representing mainly the patterns of an enormous Evershed effect. This means that the negative motion areas were bordered by areas of positive (toward the observer) motions on the side of the group closer to the disk center. These regular motion patterns were disturbed in several places by motion pairs having just reversed distribution of areas of both motions, if compared with the Evershed effect. In a few cases the negative motions in such pairs were very feable and sometimes we even observed positive velocity peaks only. In other cases they seemed to be camouflaged by the positive motion areas co-nnected with the Evershed effect.

And this very complicated pattern of the line-of-sight motions of the whole group (which may be contaminated by the Stokes V signal) was included in an extensive area of quiet photosphere motions with prevailing positive motion features.

The amplitude of negative velocities in the "reversed" motion pairs is usually substantially larger (1500-2000 m/sec) compared with the positive velocity values (800-1500 m/sec), although - as already mentioned - in some cases the negative velocity values are very small, or do not exist at all.

The relation of these "reversed" motion pairs to the topology of the magnetic field seems to be very interesting: whereas the peaks of negative velocity values mostly coincide with the magnetic field boundary, or with the zero-line of the field's longitudinal component, the areas of positive motions, with one exeption, agree with regions of the largest magnetic field gradient, regardless of the field's direction. The velocity gradients of these "reversed" motion peaks are also much stronger, compared with the velocity gradients in the Evershed motion.

SUNSPOT PROPER MOTIONS

The proper motions of the individual spots and umbral nuclei, velocities (ranging from about 10 m/sec to a maximum of 100 m/sec) and the directions of their displacements, are strongly affected by the development of magnetic activity and spot formation, and by disintegration in several areas of the group. The principal direction of proper motions is diagonal, inclined approximately

by 30° to the E-W direction. The appearance or disappearance of magnetic flux, and changes in the spot configuration are connected with the variations of direction and velocity of these proper motions. Also the regions where this occurs, as well as the radiants of the individual nuclei proper motions, seem to coincide with regions of strong "reversed" line-of-sight motions.

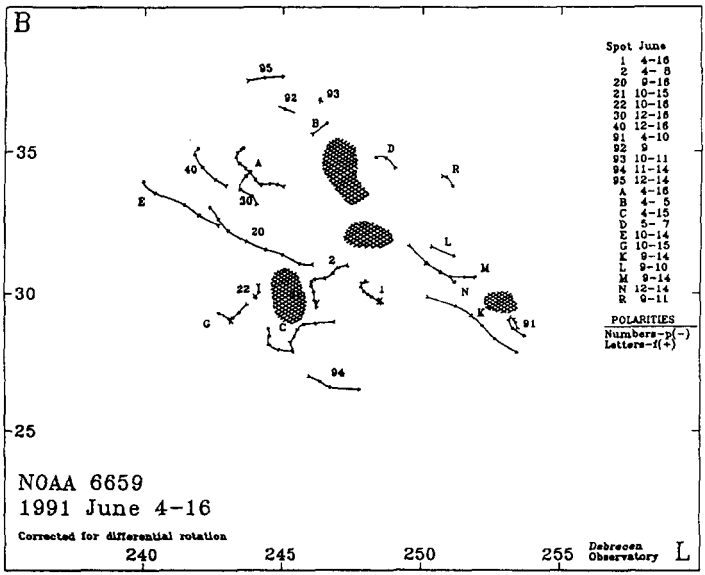

Fig. Trajectories of individual spot umbrae with schematically indicated (by hatching) areas with "reversed" motions.

RELATIONS OF BOTH TYPES OF MOTIONS TO SUNSPOT MORPHOLOGY AND MAGNETIC FIELD TOPOLOGY

Thus, the places of the occurrence of the "reversed" pairs of motions and of the sudden change of direction and velocity as well as the radiants of proper motions coincide with areas, where the greatest changes in the photosphere are observed (except the flux changes also disappearance of penumbra, desintegration of large umbrae etc.). In magnetic field topology such places are characterized also by some type of magnetic field singularity (islands of opposite polarity in the closest neigbourhood of large body of the main polarity, complicated distribution of polarities etc.). The mentioned areas agree also with the spaces from which the photospheric type light-bridges, separating the desintegrated parts of umbrae fan out.

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On the contrary, the penumbral type light-bridge, separating both main parts of the group with opposite polarities, related mostly to the maxima of negative velocity values, is the region, where the greatest part of large flares occurred.

Both types of motions (line-of-sight, proper) are probably components of the same motion system which might play a very significant role in the re-structuralization of the spot group and its magnetic field. And indeed, the correlation of areas with largest motions with regions of greatest spot group changes and magnetic field singularities underlines this idea.

We have also to take into account the coincidence of negative motions with the longitudinal magnetic field zero-line, where the whole magnetic field vector may be practically perpendicular to the negative motions vector and vice versa, the coincidence of positive motions with areas of largest magnetic field gradients, what might be explained as motions going to a cetain degree along the field lines. Also the mutual relations of magnetic and kinetic energy per cubic centimeter in both situations have to be considered.

In this way the motions may be one of the important reasons for the large flaring activity of this group. See also the main paper (Bumba et al., 1993).

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