FINE-SCAN VELOCITY AND MAGNETIC-FIELD MEASUREMENTS IN SOLAR ACTIVE REGIONS

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Abstract. Fine scan (5° × 5° aperture) simultaneous Doppler and magnetograms have been obtained over solar active regions near the central meridian passage. Besides the mainly horizontal Evershed motion in sunspots, there appears a conspicuous descending motion over all active regions. A comparison of Hα-filtergrams with the fine scan magnetograms shows that dark filaments generally lie along the neutral longitudinal magnetic zone, while the Hα-fibrils lie along the field lines, joining regions of opposite polarity.

1. Introduction

A detailed knowledge of the interaction of magnetic fields and mass motions in solar active regions is of considerable importance for an understanding of phenomena associated with active regions. Several valuable observations have been obtained of magnetic and velocity fields in and around sunspots, since the discovery of magnetic fields in sunspots by Hale and that of velocity fields by Evershed. However, little attention was paid to simultaneous measurements of both velocity and magnetic fields until the magnetographic techniques became available. Although one can obtain high sensitivity in measuring velocity and magnetic fields, there are serious limitations with magnetographs, such as, it takes a considerable time to scan a small region on the sun, limited angular resolution compared with the spectro-photographic methods and also the problem of the zero point in determining absolute velocities. Bumba (1960), Stepanov (1960), Gopasyuk (1965, 1968), Ikhsanov (1967), Frazier and Scherrer (1969), have extensively used magnetographs for either measuring velocities alone or both magnetic and velocity fields in active and quiet regions. Recently, Beckers and Schröter (1969) have made a thorough attempt to obtain simultaneous observations of both velocity and magnetic fields in sunspots using an elaborate program of determining line profiles and line positions of a Zeeman and a non-Zeeman line on spectrograms obtained over the spot region. Using the Unno-Stepanov theory of line formation in magnetic fields, they have obtained the magnetic field gradient across the spot, the inclination of the magnetic vector and the height gradient and also the sight-line velocity field in spots. Unfortunately, their method is insensitive for measuring magnetic fields smaller than 700 gauss. To obtain a complete pictorial representation of the velocity and magnetic fields over the whole active region, one would have to obtain a very large number of spectra over the whole region and to go through a very tedious process of measuring line profiles and line positions.
The Evershed effect which is a horizontal radial outflow of material parallel to the solar surface from sunspots, has been well established. The line of sight component of the velocity field continuously changes as a spot moves from the east to the west limb, thus the velocity configuration due to the Evershed motion can be completely isolated from other velocity fields in solar active regions. In this paper we present simultaneous fine scan (5" x 5" aperture) observations of velocity and magnetic fields made in both complex and simple spot groups. To minimize the effect of the Evershed motion on the measured sightline velocities and also to measure the maximum longitudinal magnetic field, we present only those observations made near the central meridian passage of the spot group.

2. Observations

For these observations, we have used the modified Babcock magnetograph of the Mount Wilson Observatory. Details of the equipment have been described by Howard et al. (1968). A 5" x 5" square aperture and the 5250A line of FeI, has been used throughout these observations. The D.C. difference signal obtained from the two photomultipliers is fed to the servo amplifier which in turn moves the exit slit assembly to compensate for the Doppler shift of the line. An encoder is coupled to the Doppler servo motor and the digital output is directly recorded on the magnetic tape. For magnetic and line intensity signals, the A.C. difference signal and D.C. Sum signal respectively, are also recorded on the magnetic tape. The line intensity signal is the sum of the intensity of the two wings of the line profile. All these three quantities along with the X and Y position on the disc are recorded on the magnetic tape. The magnetic and Doppler calibrations are generally made before and after the run of observations. These observations were made by boustrophedonic scanning method, over the active region. For reduction of the data recorded on magnetic tape, IBM 360 computer programs written by Dr. Howard and some by Dr. Rust have been used. For the Doppler and intensity records, data obtained over the whole scanned region is averaged and from the averaged \( \langle V \rangle \) and \( \langle I \rangle \) the observed values are subtracted and plotted by computer in equal velocity and intensity contour maps at assigned levels. Similar contour maps are also obtained for the magnetic field.

3. Life History of Active Regions Observed

The active region in which we obtained fine scan velocity and magnetic field, persisted for nearly five solar rotations. In this paper, we present fine scan observations obtained during its third and fourth rotations. Mr. Wilson spot group No. 17575 (henceforth the spot groups will be referred to only by the number) first appeared on September 4, 1969, at location N10 W34 as \( \alpha p \) type, on the next day it developed into a \( \beta p \) type and remained \( \beta p \) until it disappeared on the west limb on September 8. On September 22 at N11 E81 appeared a \( \beta p \) type spot group No. 17504. During its passage across the disc the spot group remained as a \( \beta p \) type and disappeared on the