Observations of Flows around Sunspot Groups

G. A. Chapman and S. R. Walton
San Fernando Observatory, Department of Physics and Astronomy, California State University, Northridge, CA, USA

Abstract. Observations of two active regions, using the Video SpectraSpectroHeliograph (VSSHG) at the San Fernando Observatory (SFO) are discussed. Both regions experienced growth in sunspot area. One, NOAA 7130, appeared to be an EFR based on $H\alpha$ images on the morning of 1992 April 16. VSSHG observations over a nearly seven hour time span on April 16 fail to show clearly organized upflow or downflows that one might expect to see for an EFR. The other region, NOAA 7260, was observed from 1992 August 12 to 21. This region showed substantial, sustained growth beginning on or before August 17 (the approximate date of CMP). There are changing regions of upflow and downflow particularly in the follower portion but the relation of these flows to the growth of the follower spot area and the magnetic field pattern is not clear.

1. Introduction

The mechanism of formation and decay of active regions is a fundamental problem for solar physics. Detailed magnetic and velocity observations during the formation of sunspots and pores and their interaction with pre-existing magnetic fields are rare.

At the SFO we have been engaged in a program to study these changes in active regions and their relation to irradiance changes. Images of line-of-sight magnetic and velocity fields and continuum intensity were obtained using the VSSHG. The VSSHG is more fully described in Chapman and Walton (1991). In addition to the VSSHG, photometric images were obtained from the Cartesian Full Disk Telescopes (CFDT) to determine changes in sunspot area and irradiance deficit. The CFDT's are described more fully in Chapman et al. (1992).

The noise levels for VSSHG images, with 0.5" × 0.5" pixels, are: line-of-sight magnetic field, 15 Gauss (flux = $2 \times 10^{16}$ Mx); line-of-sight velocity, 25 m s$^{-1}$. The approximate noise levels in the CFDT images are: spot area, 30 micro-hemispheres; spot deficit 20 ppm.

2. Observations

The observations reported here come from separate instruments and telescopes. The VSSHG usually uses the 28 cm aperture vacuum telescope and the 3 m focal length vacuum spectroheliograph and echelle grating. For magnetographic
data, we use the solar Fe I line at 6302.5 Å, which has a Lande g-factor of 2.5. The detector is a COHU CCD camera operated in the NTSC mode. The data are recorded in real time on a Sony 3/4-inch U-matic VCR in the black/white mode. The analog video tapes are processed off-line using a JVC U-matic VCR controlled by a computer containing a Matrox video digitizing board and a DSP array processor. Typically, 6 successive video frames are digitized and summed to create each line of the desired image. The size of the CCD pixels at the focal plane of the spectrograph results in a spatial pixel size of 0.51" in the resulting images. The dispersion of the spectroheliograph at the CCD is equivalent to 8.8 mÅ per pixel. However, due to the need for greater throughput, the entrance slit is widened, increasing the bandwidth to 20 mÅ per pixel. Due to seeing and telescope wind shake, the spatial resolution is typically not better than about 2". Images are usually separated in time by 75 s in order to provide some filtering of p-modes. Although the VSSHG suffers from a relatively slow scan rate (about 2.6" s\(^{-1}\)) all spectral data for each image pixel are obtained strictly simultaneously without any optical or electronic "chopping."

3. Results

A brief summary of the observational results follows.

NOAA 7130 was a short-lived EFR observed on 1992 April 16 by the VSSHG from about 1723 UT to 2312 UT. According to the SGD Bulletin, it grew from approximately 40 micro-hemispheres at the beginning of VSSHG observations to 100 micro-hemispheres at the end of observations. The region continued to grow in area, reaching a maximum area of 250 micro-hemispheres about 24 hr later. During the observations on April 16, the following were recorded: (1) Weak downflows in the interior region. (2) Strong downflows, up to 720 m s\(^{-1}\) relative to the nearby quiet Sun, at the trailing edge of the leader spot. (3) The trailer region drifted east from the leader spot, as one would expect for an EFR. (4) The p-mode amplitude was lower by a factor of 0.64 in the interior region of the EFR. There was no clear pattern of plasma upflow.

NOAA 7260 (1992 August 12-21) came over the limb as a well developed "stable" sunspot. The leader spot had an incomplete light bridge (light "peninsula") that persisted for the complete disk transit. During the first day or so of its ingress, Doppler images revealed several interesting features in the horizontal plasma flow. On August 12 and 13, we observed a superpenumbral flow pattern with an amplitude of 400-500 m s\(^{-1}\) with the same sign as the Evershed flow but ending outside the penumbra at a distance of the radius of the penumbra itself. This flow pattern is seen on the leader side of the main spot. During this same interval, the light peninsula had a red-shifted feature in line-of-sight velocity images on its disk-side.

The region's spot area grew from about 800 to 1700 micro-hemispheres during its disk transit. SFO photometric images show an increase in area from 970 to 1687 micro-hemispheres from August 16 to 19. Most of this growth occurred in the trailing region, going from zero to 700 micro-hemispheres between about August 16 to 21. There is no clear picture, particularly from Doppler images, of how the trailing part of the region grew.
4. Conclusions

We have examined VSSHG images for two solar regions that exhibited growth in sunspot area, one very strongly. In neither region can we see clear evidence in the Doppler images for upflows or upwelling of plasma that one might expect to be associated with the increase in magnetic flux and in spot area. Nor was evidence seen of thermal shadows in the continuum images. We are examining other time periods to find more active regions that exhibit rapid growth or decay.

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References


Group Discussion

November: What was the radius vector of the last set? Could this be a contribution of the horizontal velocities like Evershed flows to the Doppler velocities seen adjacent to the magnetic regions?

Chapman: Central meridian passage was about 1992 August 18. So the region was at an intermediate position. Some of the Doppler features could have a component of Evershed or anti-Evershed flow.