H/$beta$ DOPPLER-VELOCITY FIELDS WITHIN SITES OF FLARES IN A
SOLAR ACTIVE REGION

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(Received 6 January, 1993; in revised form 30 May, 1995)

Abstract. In this paper, we analyze the relationship between photospheric magnetic fields and chromospheric velocity fields in a solar active region, especially evolving features of the chromospheric velocity field at preflare sites. It seems that flares are related to unusually distributed velocity field structures, and initial bright kernels and ribbons of the flares appear in the red-shifted areas (i.e., downward flow areas) close to the inversion line of H/$beta$ Dopplergrams with steep gradients of the velocity fields, no matter whether the areas have simple magnetic structure or a weak magnetic field, or strong magnetic shear and complex structure of the magnetic fields. The data show that during several hours prior to the flares, while the velocity field evolves, the sites of the flare kernels (or ribbons) with red-shifted features come close to the inversion line of the velocity field. This result holds regardless of whether or not the flare sites are wholly located in blue-shifted areas (i.e., upward flow areas), or are far from the inversion line of the Doppler velocity field ($V_H = 0$ line), or are partly within red-shifted areas. There are two cases favourable for the occurrence of flares, one is that the gulf-like neutral lines of the magnetic field ($B_{\parallel} = 0$ line) occur in the H/$beta$ red-shifted areas, the other is that the gulf-like inversion lines of the H/$beta$ Doppler velocity field ($V_H = 0$ line) occur in the unipolar magnetic areas. These observational facts indicate that the velocity field and magnetic field have the same effect on the process of flare energy accumulation and release.

1. Introduction

Fine structures of the magnetic field and the velocity field in solar active regions are very interesting topic and have been extensively studied so far. The wavelength displacement of spectral lines in the spectra of sunspot penumbras is known as the result of the Evershed effect. The displacement of weak spectral lines is usually interpreted as being caused by a material flow directed from the umbra towards the photosphere. Maltby (1975) found that positive velocities (away from the observer) dominate on the disk centre side of the spot in chromospheric velocity maps, whereas negative velocities dominate on the limb side. This agrees with the commonly held view that the Evershed flow at chromospheric levels is directed towards the umbra. The relationship between the magnetic field and the velocity field of flares in active region has been studied by many authors. Many observational data show (Priest, 1982; Li Hongwei et al., 1987) that flares are related generally to the emerging magnetic fluxes. Hagyard et al. (1984) pointed out that the chromospheric fibrils almost became parallel to a neutral line before a solar flare. The twist of the magnetic force lines and the strong magnetic shear play an important role in the accumulation of magnetic energy and the trigger of flares (Hagyard et al., 1984). Ai et al. (1989) found that flares occurred on the red-shift side of velocity inversion lines of H/$beta$ Dopplergrams obtained one-half to two hours before flares.
The red asymmetry and red-shift of Hα flare line profiles after the initial phase of a flare have been studied by Ichimoto and Kurokawa (1984). Rust (1973) observed downward motion during and after the flare. But evolving features of the preflare velocity fields have not been studied very well. In this paper we mainly study the relationship among flare, photospheric magnetic field and chromospheric velocity field before the flare by use of the active region 5629.

2. Velocity Measurement Technique and Data Reduction

The method of measuring Hβ velocity field has been described in detail in papers about the Solar Magnetic Field Telescope (Ai, 1987). Briefly, the red and blue wings of the Hβ line (±0.24 Å from line center) are alternately selected by the filter pass-band by use of a KD*P electro-optical modulator at a frequency of 6.25 Hz. The difference of the red and blue signals divided by their sum represents the Doppler shift. A CCD is the image detector and the calculation is done by an image processing computer.

A series of the observational data of the photospheric magnetic field, Hβ flare images and the Hβ velocity field of the active region in the period from August 11 to August 14, 1989 were obtained at Huairou Solar Observing Station. These data provide a possibility to study the features of velocity fields of the Hβ preflare.

According to Solar Geophysical Data (1989) and the Hβ chromospheric observations, some small subflares occurred in the active region before August 10. Greater and more frequent flares were found after our observation began at 23:52 UT on August 10. We obtained complete time sequences of observational data on the magnetic field, velocity field, and relative filtergram in the photosphere and Hβ chromosphere during August 11–14. In Hβ chromospheric Dopplergrams the solar rotation has been removed and the fine structure of the velocity fields have been smoothed. The time interval between the Hβ filtergram and relative velocity field or longitudinal magnetic field and relative filtergram was about 1 min in general. So the superposition of the Hβ monochromatic image and relative velocity field can be executed easily.

3. Observed Phenomena

AR 5629 (S17.5, L74.3) appeared on the east limb of the solar disk on August 4, 1989. The penumbra of the major sunspot had several umbrae. Figure 1 shows the filtergrams and relevant line-of-sight magnetograms in the photospheric line Fe I λ5324.19 Å during August 7–14, 1989. The major umbrae of the sunspots are marked with u1, u2, u3, and u4 in the figures. From Figure 1(a) we can see that the relative position of the umbrae changed obviously during August 8–12. Especially, the umbra u1 of negative polarity and the umbra u2 of positive polarity