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FLARES AND VELOCITY FIELDS IN AR 5528, AR 5629 AND AR 6891

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INTRODUCTION

In regards to the spatial associations of flares to velocity fields, Martres and Soru-Escaut (1977) found that flares occurred in the vicinity of the site where the magnetic neutral lines $B_{||}=0$ and the velocity neutral lines $V_{||}=0$ lines were crossing in the photosphere; Harvey and Harvey (1976) revealed that flares were related to velocity patterns different from Evershed flows. Recently Ai et al. (1991) discovered that flares occurred on the red-shift side of the velocity inversion lines ($V_{||}=0$) of the H_β Dopplergrams observed half to two hours before flares. In this paper we further examined the associations with high resolution data obtained by Solar Magnetic Field Telescope at Huairou. A reconnection model applied to the magnetosphere is adopted here to tentatively interpret some of the observational results.

RESULTS

Around the central meridian passage of AR 5528, AR 5629 and AR 6891, complete time sequence of vector magnetograms in the photosphere (taken by the line of $\lambda 5324$Å), line-of-sight magnetograms and Dopplergrams in the chromosphere (by the line of $\lambda 4861$Å) were obtained almost simultaneously. Five flares were observed in great details from earliest brightening to the very late phase in this period.

With such a data base, we particularly examined the spatial correlations of initial brightening points at the earliest phase and the flare ribbons at the maximum phase of these flares with the configurations of velocity fields observed within 2 hours before the flares. We have fount that flares are more closely related to the velocity patterns than to that of magnetic fields. The following preliminary results are revealed.

1. Flares show much closer correlations with velocity neutral lines than

magnetic neutral lines. Among 23 initial brightening points only 10 appear in the close vicinity of the magnetic neutral lines ($\leq 4''$); and all these points are very close to the velocity neutral line ($\leq 4''$) at the same time, 6 of them are very close to the site where the magnetic and velocity neutral lines are crossing. Although the other 13 initial flaring points are more than 4 arcsec apart from the $B_{\|}=0$ lines, most of them are very near to the $V_{\|}=0$ lines ($\leq 4''$). In summary, 20 initial brightening points take place in the vicinity of the velocity neutral lines. However, almost all of the initial brightening points appear neither exactly on the magnetic, nor on the velocity neutral lines. The flare ribbons at the maximum phase also show much closer spatial relationship with the velocity neutral lines. For instance, 18 of the total 21 flare ribbons appear adjacent to the velocity neutral lines ($\leq 4''$ for the nearest distance); whereas, at least, 8 flare ribbons are more than $5''$ apart from the magnetic neutral lines.

2. On the other hand, in term of the relationship between the magnetic and velocity neutral lines, 4 categories are identified. Flares appear initially where (1) the two kinds of neutral lines cross each another nearby (6/23), or (2) the magnetic and velocity neutral lines are closely parallel nearby (4/23); (3) when the initial flaring points are quite far from the magnetic neutral lines, we often find cases that the velocity neutral lines cut across the magnetic region of same polarity (10/23). We do find 3 cases that no magnetic and velocity neutral lines pass through the vicinity of the earliest brightening. This falls in the category 4.

3. There are several curious examples that flares appear in a weak unipolar magnetic region, or a dipolar region with very weak magnetic gradient and without magnetic shear. In both situations, the transverse fields are very weak. However, it is clearly shown in those examples that flares always occur where there are strong velocity fields and/or steep gradients of velocity fields.

4. In chromosphere, the initial brightening points and the flare ribbons often occur on the edges of Evershed flow regions (near the the $V_{\|}=0$ line), or within the Evershed flow regions where small-scale non-Evershed velocity patterns present.

DISCUSSION

So far, the spatial correlations of flares and magnetic configurations have been very extensively studied. However, our limited examples show that there are much closer associations of flares to the patterns of velocity fields, at least, the velocity fields are as important as the magnetic fields for understanding flare physics. It is generally accepted that the energy released in flares are free energy stored in the non-potential magnetic fields. However, it is the plasma motions in the photosphere, or even below that generate the non-potential configurations of the magnetic field. Therefore the plasma motion seems the intrinsic energy source of flares. Moreover, the velocity patterns are crucially important in triggering the energy release.

Recently, Liu and Hu (1988) suggested a new reconnection model which suggests that the mass flows parallel to the magnetic fields are capable of generating large-scale fluid vortices by Kelven-Holmheltz (K-H) instabilities. These vortices, in turn, cause magnetic islands and X type of neutral points, and result in local reconnection. A criterion of $R = r_k/r_t = M_A(R_M)^{1/2}$ can be used to evaluate if the H-K instabilities are of importance or not. Here, r_k is the growing rate of K-H instabilities, while r_t is for the tearing model instabilities (TM), and $M_A = V/V_A$, V is the velocity, V_A is the Alfven speed, R_M is the magnetic Reynolds number. In the high chromosphere and low corona, the $V_A \doteq 300 \sim 600$KM/S, V $\doteq 10 \sim 100$KM/S, and

$R_M \doteq 5000 \sim 10^9$. Assume $M_A \doteq 0.1 \sim 0.3$, we find that $R>1$, i.e. the K-H instabilities will grow much faster than TM instabilities. The model seems reasonable to account some aspects of solar events.

In last section, we mentioned examples that flares appear in the vicinity of both magnetic and velocity neutral lines which are closely parallel. In Figure 1, we sketched the largely simplified configuration of magnetic and velocity field possibly in this case. The top part shows the magnetic lines of force; the bottom part, the stream lines. Figure 1(a) is the start configuration, and (b), (c), (d) represent the changes of magnetic and velocity field in reconnection process.

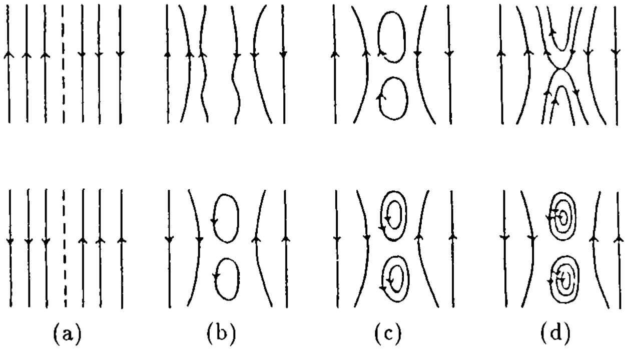

Fig.1 The reconnection configuration of magnetic force lines and stream lines

It is a puzzle why a flare could takes place in very weak magnetic region, but with very strong and complicated velocity field. Whether or not this can be interpreted by some dynamo effects, or by the fact that the magnetic field above the photosphere is strong and complicated enough to cause the flare. More examples are crucially needed to clarify this matter. A numerical simulation is undertaking by us now.

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