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Magnetic Field Reconnection in the Hα Eruptive Prominence on September 18, 1995

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Abstract. A violent evolution of the September 18, 1995 eruptive prominence is studied. The fast changes of the prominence structure started immediately after a weak radio burst on 3 GHz indicating the presence of non-thermal processes. A comparison with *Yohkoh* soft X-ray pictures was made. A detailed analysis of observations indicates magnetic field line reconnection, mainly in the space below the rising Hα prominence. The reconnection processes are manifested by structural changes of the Hα prominence and X-ray loops and also by the character of Doppler velocities in the Hα spectrum formed close to the reconnection space.

1. Introduction

It is believed that solar flares and eruptive prominences are physically connected to magnetic field line reconnection (see Rompolt 1990, Švestka and Cliver 1992, Tandberg-Hanssen 1995, Tsuneta 1996). Several papers showing good evidence of the reconnection or loop interactions are in Sakai (1993). Also, Šimberová et al. (1993) found indications of the reconnection in a large coronal arch and Smartt et al. (1994) found indirect evidence of magnetic field reconnection in coronal loops. Recently, Pevtsov et al. (1996) studied the May 8, 1992 flare associated with an Hα filament eruption and found evidence of reconnection occurring just tens of minutes before the filament eruption. We analyse the September 18, 1995 eruptive prominence with fast structural changes similar to Pevtsov's et al. (1996) flare event. As this event was situated on the limb, the reconnection processes can be studied in more detail.

2. Observations

The September 18, 1995 eruptive prominence situated on the NE limb was observed by the Hα telescope and Optical Multichannel Spectrograph, equipped with a videosystem for monitoring the Hα spectrum and slit-jaw pictures (Kotrč et al. 1993), and the Radiospectrograph in Ondřejov. The prominence activation started at about 09:15 UT with a slow rise of Hα loops followed at 09:40 UT by much faster processes. In the period 09:39 UT to 09:41 UT a weak radio burst on 3 GHz was observed. The GOES instrument registered a B4.3 soft

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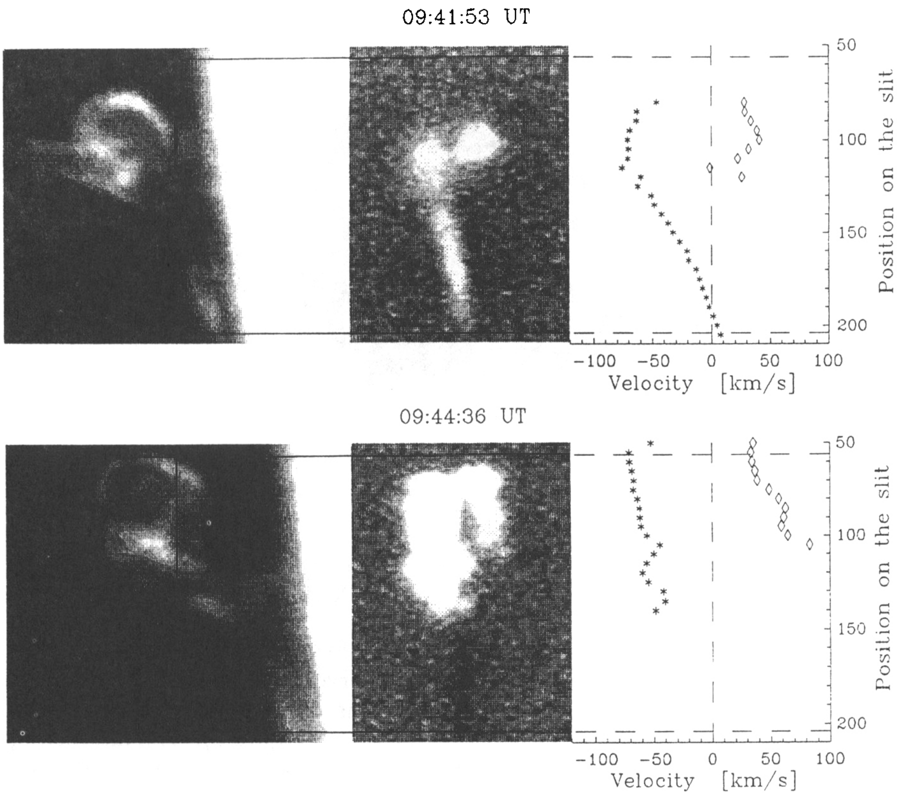

Figure 1. Slit-jaw pictures of the eruptive prominence are on the left side; corresponding Hα spectra are in the center while charts of evaluated Doppler velocities are on the right side.

X-ray flare starting at 09:33 UT with its maximum at 09:43 UT.

At 09:40 UT the Hα prominence consisted of two cusp-shaped structures (see the left hand side of Figure 1): a higher one was more open at the top, and the smaller one, which is shifted northwards seemed to be closed. This smaller structure formed a bubble-shaped loop at 09:41 UT. Simultaneously, the bottom ends of this bubble-shaped loop started to interact with the higher cusp-shaped structure. This loop interaction process continued from 09:42 to 09:43 UT, the northern side of the prominence rose higher into the corona and formed a circular structure at 09:44 UT and the open ends of the initially higher cusp-shaped structure on the opposite side of the prominence reconnected. Then, during a one-minute time interval a large chaotization of the circular structure occurred. In the following periods the prominence evolution became slower, but still its structure changed. Two Hα images and spectra are shown in Figure 1 where one can find a very crucial moment: At the places where the slit of the spectrograph cuts *the contacts of individual loops*, (i.e., at the bottom of the circular prominence structure) *the Hα spectra show large brightening and substantial*

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splitting into two separated red- and blue-shifted and, at the same time, very bright components. We fit the measured line profiles of the eruptive prominence

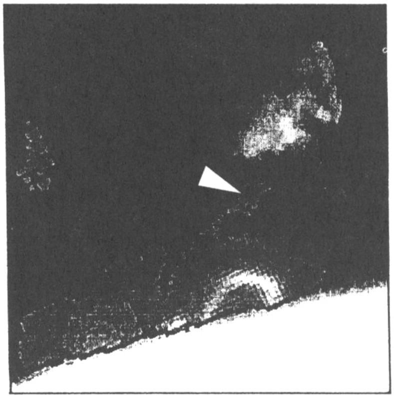

Figure 2. Hα eruptive prominence and *Yohkoh* SXT flare loops at 10:04 UT. The arrow marks interacting soft X-ray loops.

by the sum of two gaussians to derive Doppler velocities of the individual components. The *Yohkoh* soft X-ray instrument observed this phenomenon only in its final phase from 09:59 UT. To show positions of both Hα and soft X-ray structures, we made a superposition of the pictures (Figure 2). The interacting X-ray loops are situated above the closed X-ray loop but below the Hα erupted prominence material.

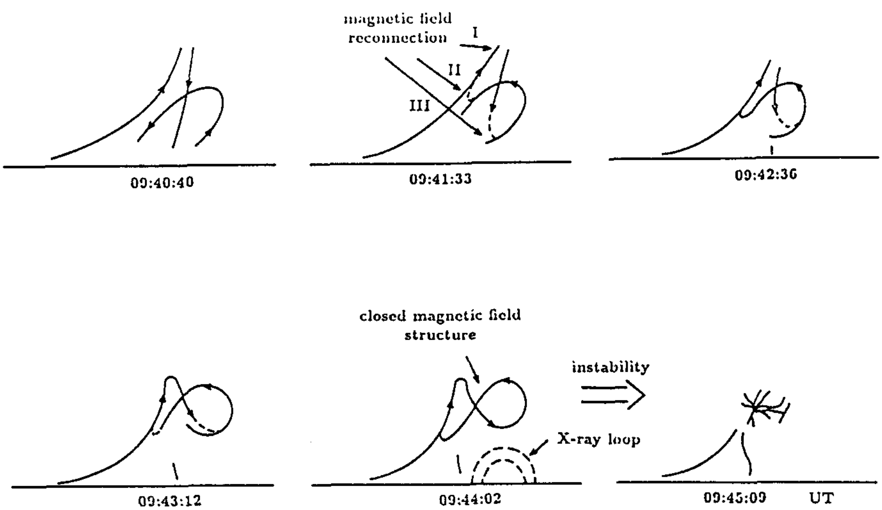

Figure 3. Prominence evolution and magnetic field reconnection.

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3. Interpretation

A simplified schematic of the prominence evolution with places of the magnetic field line reconnection is shown in Figure 3. We assume the magnetic field lines to be parallel to the shape of Hα loops. Obviously, only their relative orientation is important for reconnection. At the beginning of the evolution the upper part of the Hα prominence shows cusp-structures. We found three places (I, II, and III – see Figure 3), where the magnetic field reconnection is very probable. We think that only reconnection can explain the fast changes of the prominence structure. The most important reconnection process was probably at place III. Namely, the reconnection can explain not only changes of the prominence observed in Hα (circular structure), but also the presence of closed X-ray loop observed below this reconnection place by *Yohkoh* (Figure 2, in Figure 3 this hot loop is expressed by dashed lines). The X-point of the magnetic field reconnection is expected just between both these structures.

This reconnection scenario can be also supported by the observation of the X-ray loop interaction between the closed X-ray loop and arising Hα prominence (Figure 2). The Hα line splitting into red and blue Doppler shifted components at place III represents further evidence of the reconnection process. Namely, as known from the magnetic field reconnection theory, a plasma with the magnetic field flows into the X-point where the reconnection process takes place. We suggest that just in these inflowing plasmas (in the direction from and towards an observer) the enhanced Hα emission with line splitting is generated at place III. Consequently, the Doppler velocity components in the Hα spectrum (typical values are of the order $\pm$ 50–100 km s^{-1}) we can interpret as the centerward velocity field of the inflowing plasma into the place of reconnection.

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