EJECTION OF HEATED MASS INTO A HELIX-LIKE STRUCTURE FROM ACTIVE REGION NOAA 7172 ON MAY 21–27, 1992

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Abstract

Following an extended soft X-ray flare on May 19, 1992, the magnetic structure related to the active region NOAA 7172 settled down into a roundish agitated active region with a helix-like structure extending in the south-west direction. Repeated ejections of heated mass into the helix-like structure took place from a point of contact between the helix-like structure and the agitated active region. We discuss two of these mass ejection events occurred on May 21–22, and May 26. The three-dimensional velocity in the event on May 26 could be examined through a coordinated use of the relevant part of the brightening of the images from the Soft X-ray Telescope (SXT) and the integrated intensity of the blue-wing profile of the S XV resonance line from the spatially non-resolving Bragg Crystal Spectrometer (BCS).

1. Introduction

The events described in this paper consisted of repetitive mass ejections into a helix-like structure from the interface between this structure and an agitated active region (NOAA 7172), following a flare which occurred in the same active region on May 19, 1992. The flare was associated with the disappearance of a very dense H_α dark filament which almost contacted the major spot in the active region from the north.

We use S XV spectra recorded by the Bragg Crystal Spectrometer (BCS) on board *Yohkoh* together with the images from the Soft X-ray Telescope (SXT) to discuss the three-dimensional velocity of the ejected plasma and the rate of mass ejection in these events. Although BCS has no spatial resolution, we can identify the source of the S XV emission by selecting a part of the source showing a similar time variation of intensity in the spatially resolved SXT images. Thus we can infer the line-of-sight velocity together with the proper motion velocity in that brightening event (cf. Uchida et al. 1994). We obtain in this way the three-dimensional velocity for the mass ejection event of May 26, 1992. From a knowledge of the density in the ejection and the density in the source region together with the three-dimensional velocity, we discuss the mass flux from the source point which may serve as a clue to the rate of magnetic reconnection occurring there. Here we report the preliminary result of examination of these events. More detailed quantitative discussions will be given in a separate paper.

2. Observations

2.1. Overall Description

The active region NOAA 7172 produced a low energy diffuse flare on May 19. A very dense H_α dark filament, elongated north-south, which had been almost in contact with one of the major spots in the active region, disappeared and a large amorphous soft X-ray arcade was formed. The soft X-ray structure settled into a roundish, agitated active region with a helix-like structure extending toward south-west.

Repeated ejections of hot mass into the helix-like structure from the interface of these two structures occurred from time to time for over a week in a recurrent manner. We examine two typical events, and discuss the physical process taking place in these hot mass ejections.

2.2. May 21 – 22 Activity

The mass ejection into the helix-like structure from the interface between the active region and the structure (possibly a relaxed magnetic rope) that we deal with here started on May 21, at around 22:30 UT, and lasted until May 22, 01 UT. The ejected mass streamed along a loop which spans a part of the helix-like structure (Figure 1).

Fig. 1. The event of the heated mass ejection into a helix-like structure of May 21 – 22, 1992. The ejection started from a point near the magnetic pore of opposite polarity in the region B.

The estimated velocity (proper motion velocity in projection) derived from the velocity of the progressing front in the loop seen in SXT images is about 110 km/s.

The Kitt Peak magnetogram at the time closest to that event (14:40 UT, May 22) showed that the magnetic polarity of the big spot (denoted A) on the east side in the active region and the region on the north-east end of the helix-like structure (denoted B) have one polarity, whereas the polarity of the spot on the western side in the active region (denoted C) and the south end of the helix-like structure (denoted D) was opposite. The loops coming from C and D are grounded in the region, B, located to the south of the active region. The loops coming from C and D which are in contact there have the same magnetic field direction, and magnetic reconnection between them raises a problem. A closer examination, however, shows that a very small opposite polarity pore existed in the region B, and it is possible that magnetic reconnection took place there. Also, it is to be remarked that the loops connecting the spot C to the region B are seen to have a shear, thereby connecting the spot to a part somewhat shifted from the closest part in the opposite polarity region surrounding it. The sense of the twist in the sheared connection seems to be the same as that of the apparently helical south-west structure coming into the footpoint region B. Therefore, the senses of the toroidal fields are opposite to each other at the interface of these two sets of bundles.

There are, therefore, possibilities that the heated mass is injected from magnetic reconnection taking place (i) between the magnetic fields of the patch and those connecting to the region surrounding it, or (ii) between the oppositely directed toroidal components of the helical magnetic flux tubes in contact, one connecting the region B to the spot C, and the other connecting the region B to the south-west region D. The reconnection process occurring in cases (i) and (ii) will be discussed quantitatively in the fuller paper.

2.3. May 26 Activity

The event which occurred on May 26 when the active region came close to the west limb had a particular importance among the sequence of these mass ejection events, as in this event we could identify for the first time the blueshift in S XV line for faint non-flare events with an observed flow of hot gas along a magnetic loop. This was possible due to the relatively quiet activity in the surroundings at the time of this event.

Fig. 2. The event of heated mass ejection occurred on May 26. From the correspondence with the structure of the earlier days, say May 21, we may identify the part in the middle which brightened up and produced heated mass flows both toward the active region and toward the helical structure with the region B. From the geometry of the field lines in the May 21 event, the hot mass first moved toward the observer, then going up high, and moved away, all along a helical loop in the case of mass ejection into the helix-like structure.

Figure 2 shows the time development of the May 26 mass ejection event into a helix-like structure that occurred between 02:58 - 24:30 UT. The brightening that occurred at the north end of the helix-like structure (around the middle in the picture) progressed both toward the active region on the north and the helix-like structure still existed on the south–west.

The most significant point in this event is that we could measure the Doppler velocity in the S XV resonance line. Figure 3 shows the ratio of the intensity integrated over the wavelength range corresponding to the velocity range of 150-350 km/s in the blue wing of the S XV resonance line, divided by the intensity at the peak of the line. It can clearly be seen that the blue-shifted emission is enhanced in the period 04:54 UT through 05:02 UT, with its maximum occurring at around 04:57 UT. This, when compared with the time profile of the total intensity in the S XV channel also shown in Figure 3, is seen to occur at the time of the steepest rise of the S XV lightcurve, suggesting that the S XV emitting gas is supplied by this ejection.

Since BCS S XV spectra have a contribution from all active regions present on the solar disk, we performed an additional check, where the averaged S XV spectrum seen before the brightening was subtracted from the spectra taken during the event, thus removing the contribution from the surrounding active regions. After this correction, the S XV spectra confirm, although with somewhat greater statistical noise, the reality of the blue-wing/center behavior seen in Figure 3.

If we assume that the structure had a basically similar shape (helix-like shape) as seen from above in the May 21 event, the heated mass streams along a helical loop, first eastbound, and later in the south-west direction after rising high along the helical loop. The projected proper motion velocity derived is about 150 km/s, while that derived from the Doppler velocity is somewhere around 150 – 200 km/s. If we assume in a very rough approximation that the streaming velocity does not vary along the path (not a good approximation though) and the velocity in the lower part of the loop in which the hot mass moves eastbound is roughly the same as the velocity which streams along the helical loop towards south-west part of the loop later, the angle that the lower part of the loop makes with the line-of-sight is within 30 - 45 degrees, coinciding with the orientation angle of the loop seen from the top in the May 21-22 event. More accurate analysis in the future will provide us with a more accurate information about the three-dimensional velocity. We will discuss this in connection with the determination of the rate of mass flux through the magnetically reconnecting point which allows the hot plasma to be injected into the helix-like loop.

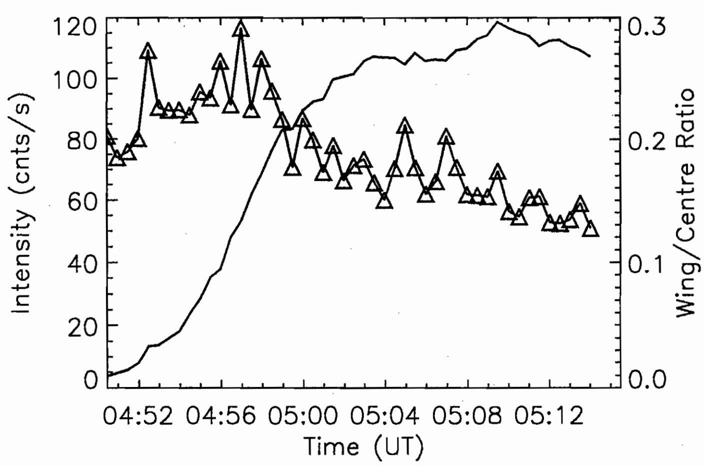

Fig. 3. The integrated intensity in the S XV channel (continuous line) and the ratio of the blue wing of the S XV resonance line integrated in the velocity range 150 - 350 km/s to the intensity at the line centre (triangles), during the brightening event of May 26, 1992. The pre-brightening background of 75 cnts/s was subtracted from the intensity.

3. Discussion

In the present paper we presented a preliminary report on a typical event of mass ejection from a heated bright point into another magnetic structure. So-called "X-ray jets" (Shibata et al. 1992) are the special case of the mass ejections of this type, but into an open and straight magnetic field.

There are still two possibilities for the magnetic reconnection processes involved as described in section 2.1, and a more detailed analysis is being made to discuss the rate of heated mass transfer in such events, and together with the knowledge of the density at the reconnecting region, we will have some information about the rate of the magnetic reconnections. The results of these analyses will be found in a later paper.

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References

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