X-Ray Activity in Coronal Loops and Its Photospheric/Chromospheric Counterparts

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Abstract

Brightenings seen in X-ray coronal loops are compared with Hα and magnetograph observations obtained at Mitaka. An indication of magnetic field changes of about 50 gauss is found at a footpoint of a loop in association with its X-ray brightenings.

1. Introduction

Now it is generally believed that flares take place when the magnetic field has accumulated excess energy. A most likely form of magnetic field which stores excess energy is the so-called sheared magnetic field. Magnetic field observations often showed that after a flare the shear relaxes (Sakurai et al., 1992). The aim of this study is to investigate whether such magnetic field changes are found in smaller scale events, for example loop brightenings seen in X-ray coronal loops in active regions (Shimizu et al., 1992).

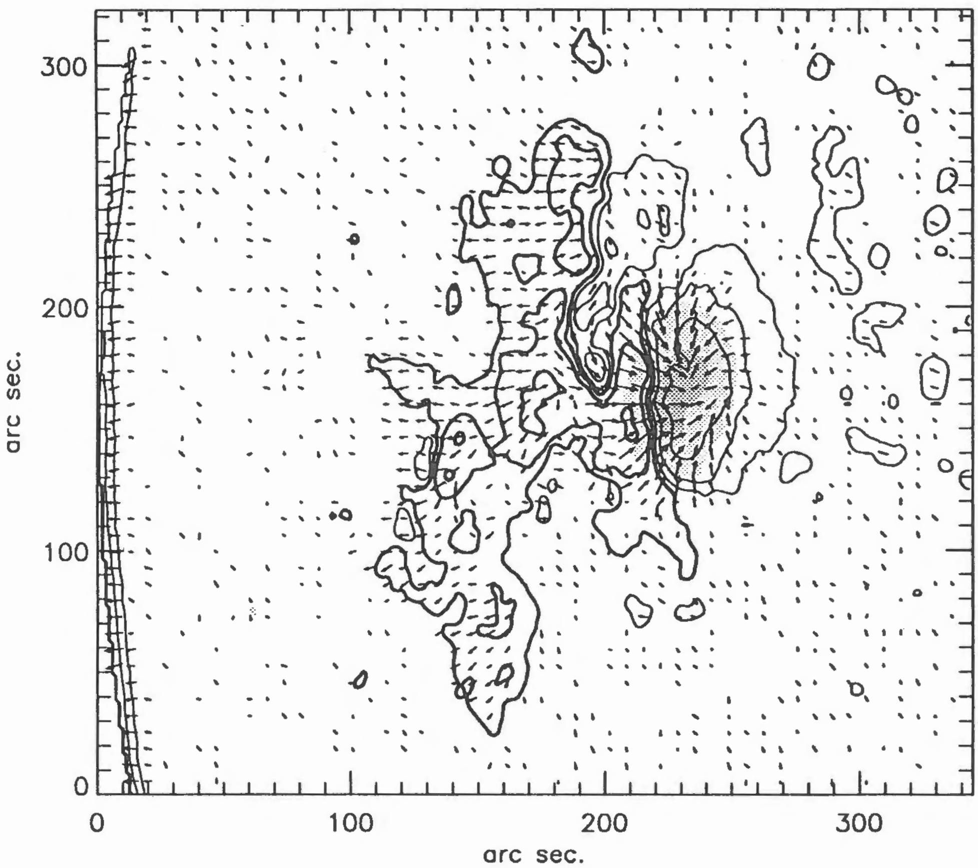
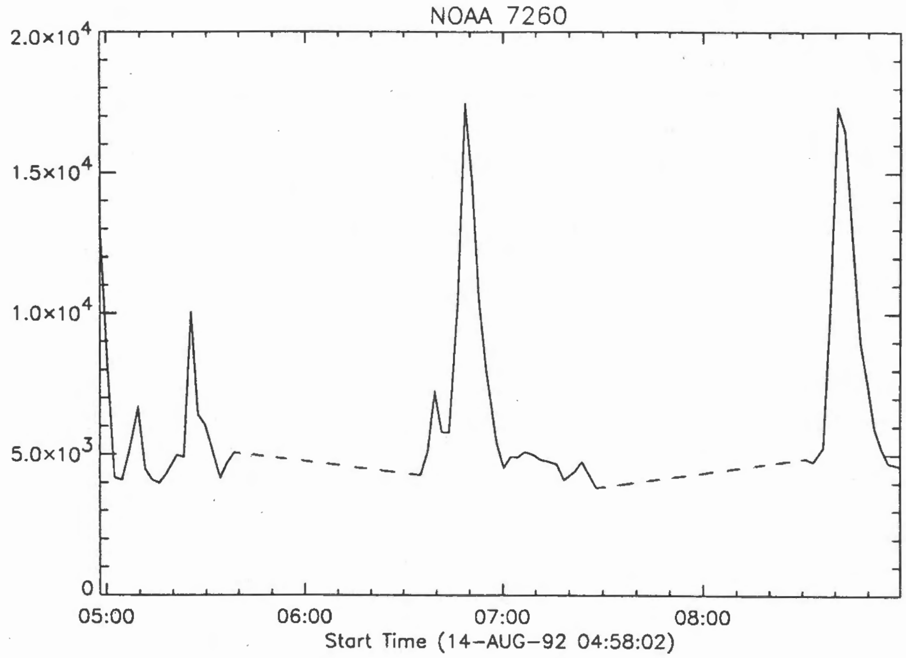
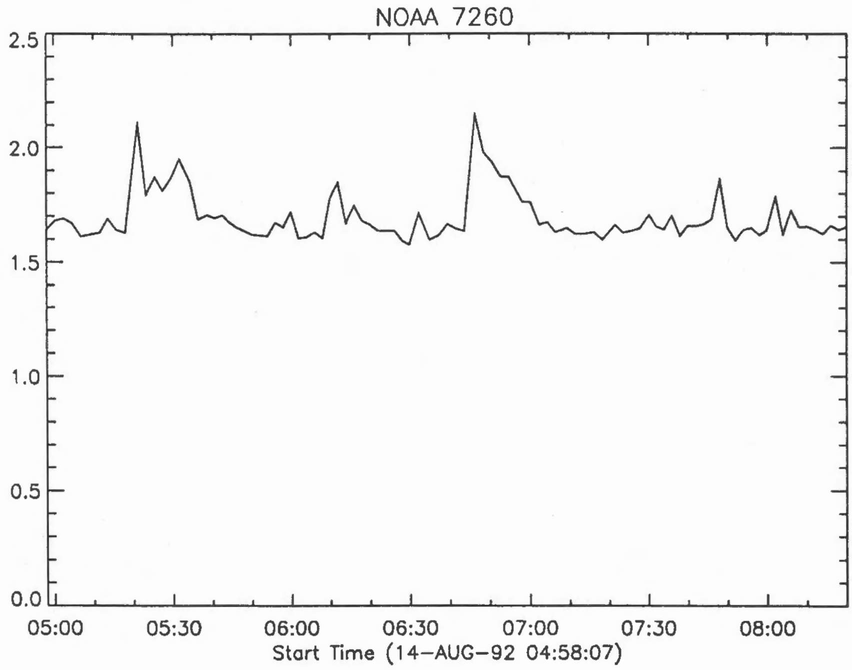


Fig. 1 A magnetogram of NOAA 7260 on 1992 August 14 observed with the Solar Flare Telescope



(a) X-ray Light Curve



(b) Hα Light Curve

Fig. 2 (a) X-ray and (b) Hα light curves of NOAA region 7260 on August 14, 1992.

2. Observations

We picked up the region NOAA 7260 of August 14, 1992. The Solar Flare Telescope at Mitaka (Ichimoto et al., 1991) had continuous magnetogram coverage for three hours from 04:56 UT to 08:19 UT, with 3 minute cadence (figure 1). Within this interval, the soft X-ray telescope of Yohkoh (SXT) had its partial frame observing region pointed at the same region. The images were taken through Al 0.1 μm and Al 1.2 μm filters, with a format of 128 × 128 pixels. The resolution was 2.5 arcseconds per pixel. Through each filter, images were taken every 2 minutes, with night gaps of about 50 minutes. We only use the data taken through Al 0.1 μm filter covering the interval between 4:58 UT and 8:59 UT. For the overlay of X-ray and magnetograms, we used optical images taken with the aspect sensor of SXT.

Figure 2a is the X-ray light curve of this region during the observing period mentioned above. The brightness of the brightest pixel in the field of view is plotted in this figure. In the same manner, figure 2b shows the Hα light curve of this region obtained from the video disk recording of Hα images with the Solar Flare Telescope. Several brightening events were found, which took place in the loops emanating from the east-side (limb-side) penumbra of a large sunspot.

Figure 3 shows an example of X-ray brightenings which took place at 0646 UT. By makeing a difference between the brightening and the pre-brightening images, the brightening in a small loop becomes clearly visible.

Figure 4 shows the Hα image taken near the time of the X-ray brightening of figure 3, and two points located at the footpoints of the X-ray loop showed brightenings.

The overlay of X-ray images and magnetogrms shows that the loops ran across the magnetic neutral line with a very acute angle, indicating sheared magneric field. Because the region is close to the limb, the spot showed the so-called shadow (inverse) polarity on the limb-side of the spot. Although both footpoints of the loops were apparently rooted in the same magnetic polarity, the correction of the view angle effect shows that actually the loops connected the opposite polarities.

3. Magnetic Field Changes

By viewing magnetograms as a movie, it is noticed that the magnetic field changes in a restricted area which coincides with the south-western footpoint of the X-ray loop that showed brightenings (figure 5). The time variation of the magnetic field in this region is shown in figure 6 together with data from other (control) points. The magnetic field change associated with loop brightenings was detected with the magnitude of about 50 gauss in the longitudinal field. Since the region is 50 degrees east of the central meridian, the change can be explained if the loop which had run nearly parallel to the solar surface became slightly elevated with respect to the surface. The change is rather gradual and it is not certain whether the magnetic field change is the cause or the result of the loop brightenings.

References

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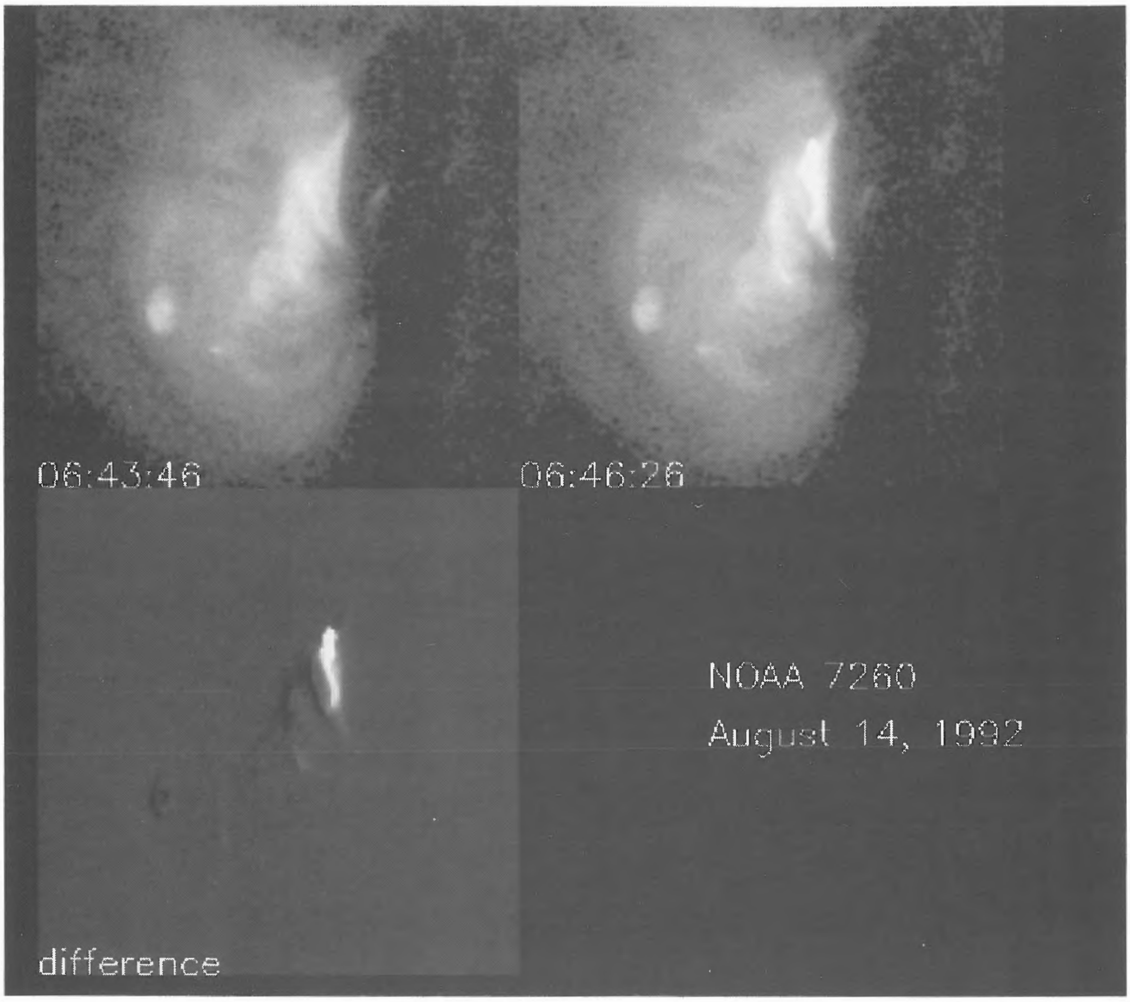

Fig. 3 Yohkoh soft X-ray images of the loop brightening at 0646 UT. The difference image (lower left) is made from the two frames taken at 0646 UT (at the brightening) and at 0643 UT (before the brightening).

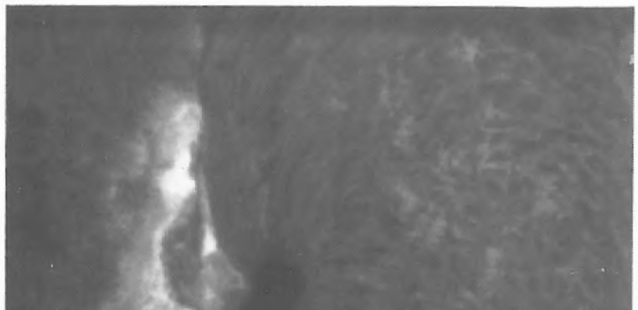

Fig. 4 Hα brightenings at the foot point of the brightened X-ray loop.

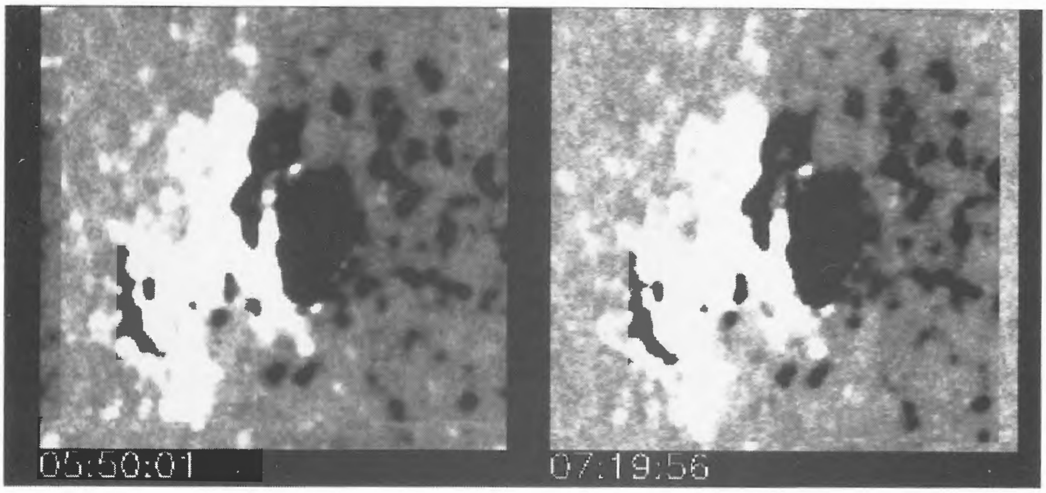

Fig. 5 Longitudinal magnetograms in gray scale representation, taken 80 minutes apart. The disappearance of a patch of positive (white) polarity is clearly seen.

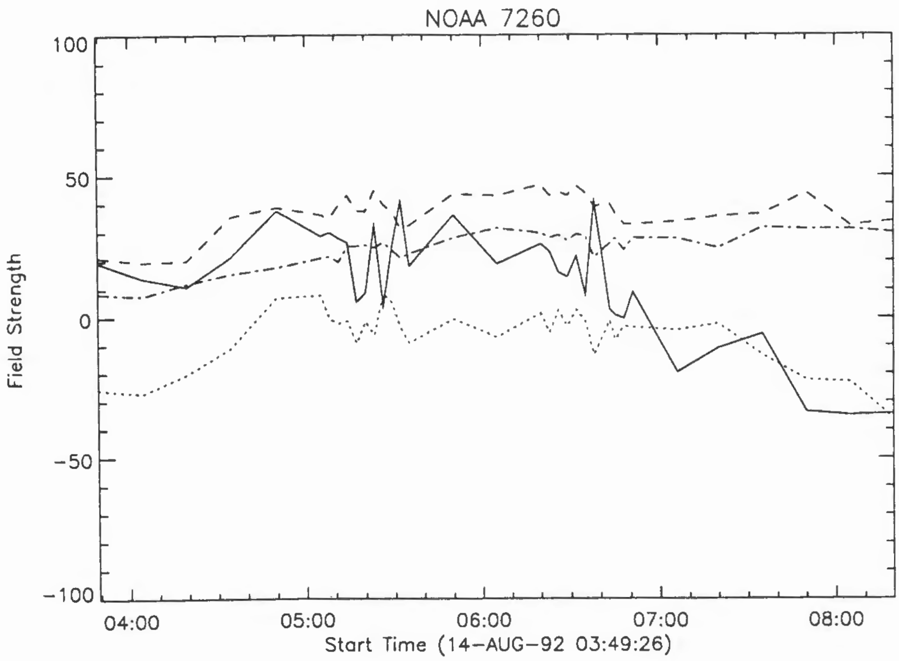

Fig. 6 Changes of magnetic fields in time. The solid line corresponds to the patch of disappearing positive polarity in fig. 5. The other points (indicated by dotted, dashed, and dot-dashed lines) do not show such systematic variations.