Multi-Wavelength Observations of a Large-Scale Jet and an Eruptive-Prominence on 28 August 1992

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Abstract

An eruption of a large (15°) north-south aligned quiescent prominence and associated coronal disturbance, which took place above the eastern solar limb near the equator on 28 August 1992, were observed at a wide range of wavelengths ranging from soft X-rays (Yohkoh) to microwaves (Nobeyama). The eruption was preceded by the formation of a large-scale jet which was apparently ejected near the root of the southern leg of the prominence. The characteristic outward speed of the jet was 450 km s^{-1}. A potential-field presentation of the coronal magnetic field suggests that the jet was formed along the open field which was located immediately to the west of the magnetic arcade, originally surrounding the eruptive prominence. The temperature of the jet is suggested to be comparable to that of the nearby quiet corona (2×10^6 K). In the course of the prominence eruption, helically twisted loops surrounding the prominence were observed. This suggests that magnetic reconnection of the sheared arcade took place underneath the erupting prominence.

1. Introduction

We perform a case study on an eruptive prominence which was observed above the eastern solar limb, near the equator, on 28 August 1992 because the data coverage is remarkably good (Watanabe et al., 1998). A large-scale jet was formed immediately before the eruption of the prominence. First, we examine observations of the jet and then the soft X-ray fine structures surrounding the eruptive prominence.

2. Soft X-Ray Jet

A large soft X-ray jet was observed near the southern leg of the eruptive prominence about three hours before the eruption. A series of Yohkoh SXT images showing the jet are shown in Figure 1. The jet was observed in the interval from 18:31:10 UT to 18:48:50 UT on 28 August. A previsional temperature estimation of the jet is performed using the pair of Al.1 and AlMg images taken at the minimum time difference (128 seconds). The expanding speed of the jet is estimated to be about 450 km s^{-1}. As shown in Figure 2, the jet showed an equatorward swing with a characteristic speed of 125 km s^{-1} near the uppermost tip of the jet, during the filter-pair observations. This rapid motion of the jet makes the temperature estimation difficult. To minimize the uncertainty in the temperature estimation, we selected an area along the axis of the jet (shown in Figure 2 by the rectangular box) assuming that the physical conditions within the area did not change during the filter-pair observations. The obtained temperature is 2×10^6 K, which is comparable to that of the nearby background corona. From the estimated emission measure of the jet ($\sim 1.0 \times 10^{28}$ cm^{-5}), we obtained the following physical parameters of the jet: electron density $\approx 1.7 \times 10^9$ cm^{-3}, mass $\approx 9.2 \times 10^{14}$ g and kinetic energy $\approx 9.3 \times 10^{29}$ erg.

The potential magnetic field based on Kitt-Peak magnetograph observations in the coronal region including the jet and the eruptive prominence is shown in Figure 3, viewed from different aspects. We assume that the source surface is located at 2.5 solar radii. This figure shows the magnetic topology on 28 August 1992 (a), and the top-view of the region of the eruptive prominence rotating the sun by 90° (b). For comparison, an example of soft X-ray image

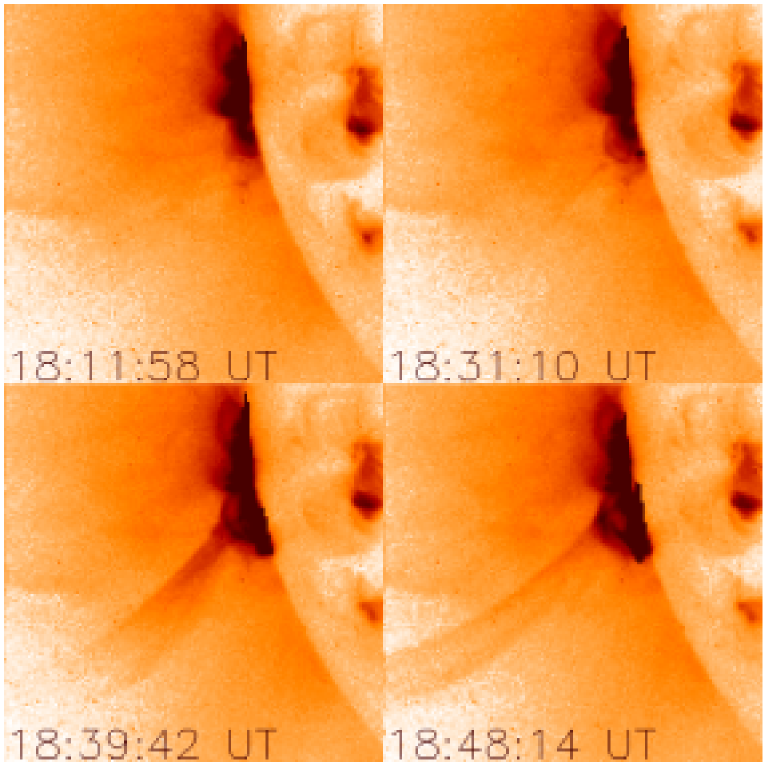

Fig. 1.. Soft X-ray images of the jet in the interval from 18:11:58 UT to 18:48:14 UT on 28 August 1992.

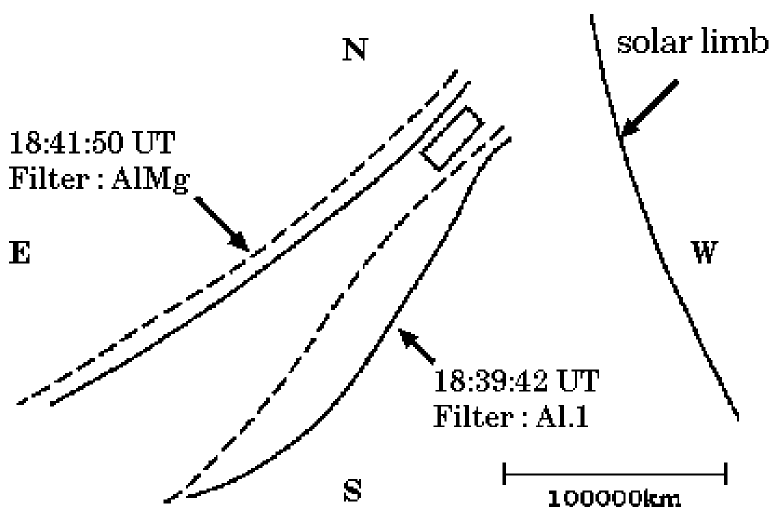

Fig. 2.. Schematic geometry of the jet at 18:39:42 UT (Al.1 filter) and 18:41:50 UT(AlMg filter) on 28 August 1992. The rectangle shown in this figure represents the region where the temperature is estimated by the filter pair method. The size of this region is about 3×10^8 km^2 (30 pixels; 1 pixel = 4.92$''$).

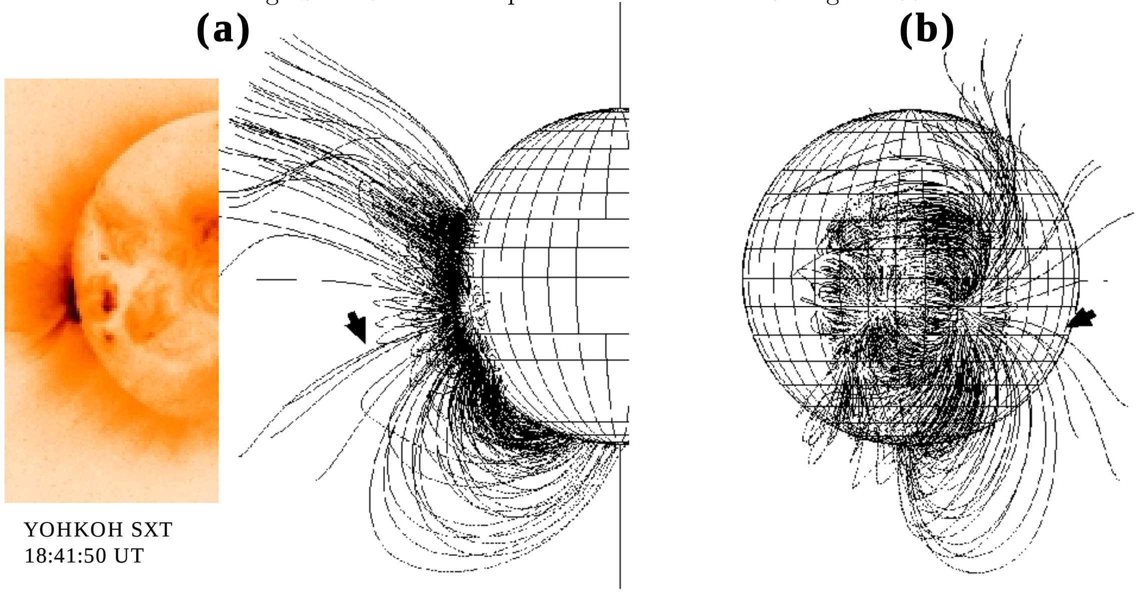

Fig. 3.. The potential magnetic field topology in the solar corona above the region of the prominence eruption of 28 August 1992. The left figure (a) the magnetic field topology on 28 August 1992 and an example of soft X-ray image of the jet (taken at 18:41:50 UT). The right figure (b) is the magnetic field topology of the same region but rotated by 90° to show the top view of the region. The jet was observed, apparently, along the open field lines indicated by the arrow in each frame.

of the jet (taken at 18:41:50 UT) is also shown in frame (a). The jet apparently appeared to follow the open field indicated by the arrow in the figure3 (a). According to figure3 (b), the open field was located to the west of the magnetic arcade surrounding the eruptive prominence.

3. Eruptive Prominence

We use soft X-ray images (Yohkoh), Hα images (Boulder, Holloman, Norikura, and Hida), and 22 GHz radio images (Nobeyama) in the present analysis. The most interesting X-ray feature of the event is the presence of highly complicated loop structures surrounding the erupting prominence. A sketch of the loops and the prominence is given in Figure 4. Kinky helical loops and smooth loops apparently passing through the center of the helical loops are seen around the erupting prominence. Although it is difficult to know the 3-D configurations of these loops, a combination of helically twisted loops and more smooth loops passing through the axis of the helical loops can be identified.

4. Concluding Remarks

This event will be one of the "best" examples of prominence eruptions ever observed by Yohkoh. Since the prominence eruption took place shortly after the appearance of the jet, a close conection between the jet and the eruptive prominence is suggested. The jet largely followed the potential magnetic field with an open configuration. The speed and the kinetic energy of the jet is comparable to those of microflares (Tajima and Shibata, 1997).

The helical configuration of loop structures surrounding the eruptive prominence is largely similar to that proposed by Ballegooijen and Martens (1989) to create twisted flux tubes above magnetic neutral line. They showed that twisted flux tubes are formed by the development of sheared, prominence-supporting field due to flux cancellation above the neutral line. They also suggested that prominence eruption can be caused by this process.

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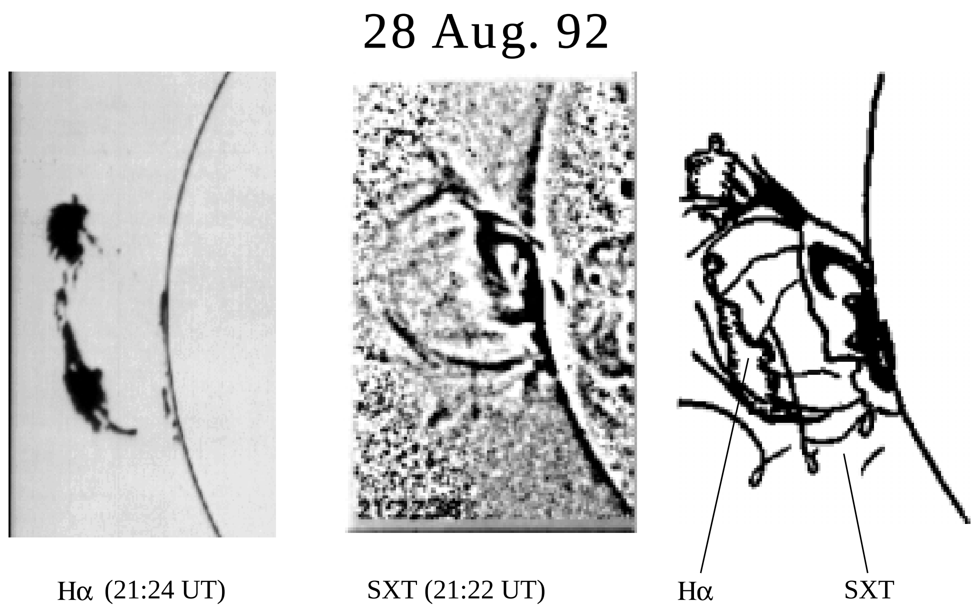

Fig. 4.. An Hα image of the eruptive prominence of 28 August 1992 at 21:24 UT taken at Norikura (left), an enhanced-contrast image of the soft X-ray during the eruption (center), and a sketch of soft X-ray loops at 21:31:08 UT (right). The schematic configuration of the eruptive prominence is also shown.

References

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