METRIC TYPE III BURSTS FROM FLARING X-RAY BRIGHT POINTS

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Abstract

X-ray bright points (XBP's) are known to show variability on a number of timescales, including impulsive X-ray brightenings. The relationship between these XBP "flares" and normal solar flares is poorly known. A fundamental question is whether nonthermal acceleration of particles takes place in XBP flares. We address this issue by searching for nonthermal radio emission at metric wavelengths from flaring XBPs identified in Yohkoh/SXT data. Unequivocal evidence for type-III-like radio bursts, usually attributed to beams of nonthermal electrons on open field lines, is found. This suggests that XBP flares are similar to normal flares and can indeed accelerate nonthermal populations of energetic particles.

1. Introduction

Solar X-ray bright points (XBP's) are compact emitting regions associated with bipolar magnetic fields. Their properties as deduced from Skylab observations have been discussed by Golub et al (1974,1977). At any one time there appear to be dozens of XBPs present on the sun. Their life times range from a few hours to several days, although only a small number appear to last over two days. They are known to flare. Between 1975 and 1991 there were no satellites capable of observing coronal bright points in soft x-rays, and their study has been possible only during brief rocket flights. The launch in 1991 of the Japanese satellite *Yohkoh*, carrying a soft X-ray telescope of unprecedented resolution now provides excellent images of X-ray bright points with high time resolution on a regular basis (Nitta et al 1992; Strong et al

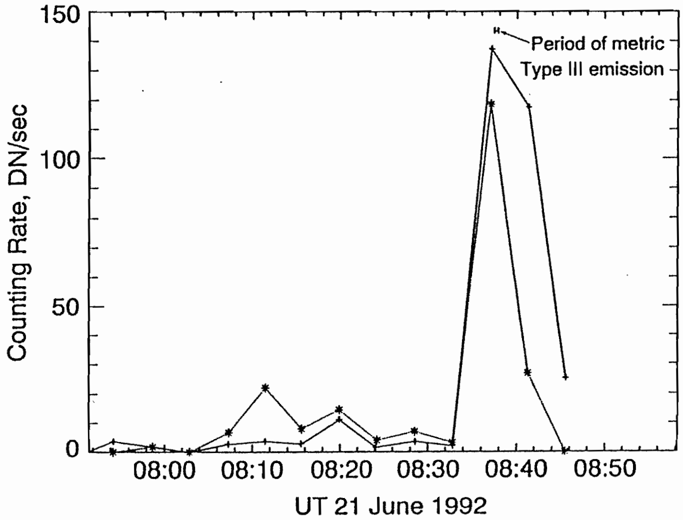

Fig. 1. The soft X–ray time profile of two pixels at the location of XBP in the eastern edge of the coronal hole in the NE quadrant for one orbit, showing an XBP flare.

1992), and joint studies of XBPs with observations at other wavelengths are timely. From Skylab data it was known that about 10% of XBPs exhibit a type of sudden,substantial increase in surface brightness which in larger regions would be termed flaring. These flares appear to be impulsive in nature, lasting only 2–3 minutes. One of the most important aspects of bright point flares which has not been studied is whether or not XBP flares produce nonthermal populations of energetic particles. Evidence of nonthermal emission can be obtained, among other observations, from observations of metric type III radio bursts from flaring XBPs. Kundu, Gergely & Golub (1980) using the Clark Lake Radio Observatory interferometer data found a 10% association between flaring XBP's and Type III's. In this paper, we present the results of a study of radio emission at meter wavelengths from flaring X-ray bright points,using the *Yohkoh SXT* data along with the Nancay Radioheliograph data at meter wavelengths.

2. Observations

A search was made for meter wave radio emission from more than a dozen coronal bright points observed in soft X-rays by the Yohkoh/SXT experiment on 1992 June 20 and 21. The radio observations were carried out with the Nancay (France) Radioheliograph (NRH) at five frequencies in the range 150–450 MHz. Several cases of metric radio emission unambiguously associated with isolated flaring XBPs have been found based upon temporal and spatial coincidence of the XBP flares observed by Yohkoh and the radio emission observed by NRH. The metric radio emissions appear to be type-III bursts, which are produced by nonthermal beams of electrons: this represents strong evidence that the XBP-flare mechanism is capable of accelerating particles to nonthermal energies, as well as producing the heated material detected in soft X-rays.

3. X-ray properties of XBP's

The X-ray observations of the XBP flares were made with the *Yohkoh* SXT experiment. As observed by SXT there was an XBP flare on the eastern edge of a low-latitude extended coronal hole. The XBP existed from at least 22:12 hours on 1992 June 20, and it exhibited fluctuations in brightness from time to time, sometimes approaching levels where they would be called XBP flaring. In this paper we will be concerned with this XBP and another in the

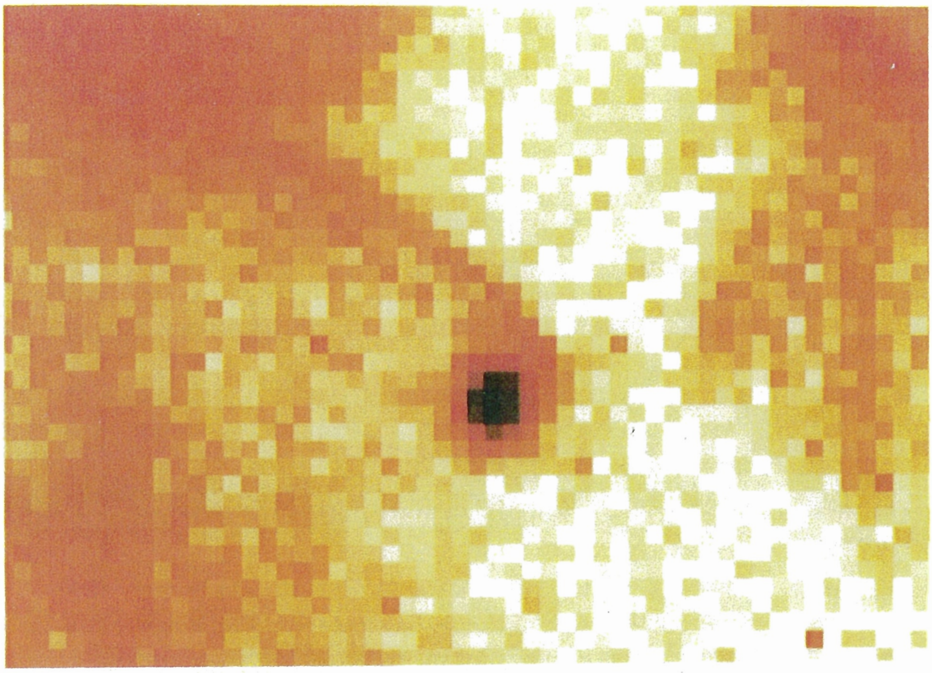

Fig. 2. An SXT image of a jet emerging from the NE coronal–hole XBP at 22:29 UT on 1992 June 20.

north-west quadrant. A time profile of the first XBP flare is shown in Fig. 1. The X-ray flare lasts about 10 min, peaking at 0837 UT. Type III bursts were observed from the vicinity of this XBP, peaking at 083730 at all three frequencies, and will be discussed below.

The SXT image at 222910 (June 20) shows a faint wisp-like feature emanating from the same bright XBP (see Fig. 2). This feature is believed to be real. We should note that such jet-like features have been noted by Strong et al (1992) in connection with XBP structures observed by Yohkoh SXT experiment. ¿From analysis of the X-ray emission from this XBP seen through several filters at 22:20 UT we deduce a temperature of $\sim 5 \times 10^6$ K and a peak emission measure of $10^{46.7}$ cm^{-5}.

4. Radio Emission from XBP's

The type III bursts observed in conjunction with the XBP flare near the eastern coronal hole were rather weak, $\sim$ 20 sfu at both 164 and 236 MHz with 1 s time constant. They were also observed at 327 MHz with 10 s time constant. They were not polarized at 164 MHz, the polarization being $< 5\%$; at the other frequencies the polarization was not measurable. Their angular sizes were $\sim$ 2 arcmin E-W at 164 MHz; the size was very small (unresolved) in the N-S dimension. The brightness temperatures were $\sim 10^9$ K. The peak times of type III emission at the three frequencies coincided well within 10 sec and at the two lower frequencies within 1 sec. The positions of type III's coincided well within the error bars, which gives credence to the belief that they originated from the same cause, namely the XBP flare. The positional points are close together, but they are not exactly at the same location. There appears to be a small dispersion of position with frequency in Fig. 3; the highest frequency (327 MHz) is closest to the center and the lower frequencies are farther away from the center. This dispersion in position with frequency is consistent with plasma emission process for type III's. From this positional data one can infer that the type–III–producing electron beam propagated

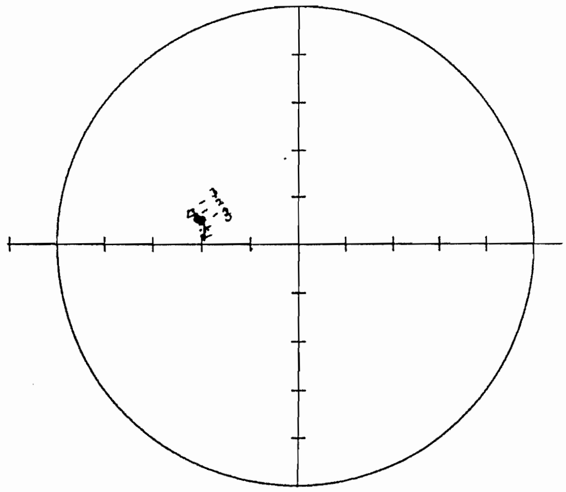

Fig. 3. Positions of radio bursts at 08:37 UT at three different frequencies: 1 = 164 MHz, 2 = 236 Mhz, 3 = 327 MHz.

in the north-east Note that the direction of the jet-like feature in Fig. 2 agrees reasonably well with the path of propagation of the electron beams responsible for the type III's.

5. Summary

We have demonstrated that the XBP flares can give rise to nonthermal emission in the form of type III-like radio emission from electron beams, in addition to thermal soft X-ray emission from the heated plasma. The radio bursts associated with XBP flares are very weak and nonspectacular in appearance, and are observed to be of restricted bandwidth. As in normal solar flares, the electron beams appear to be produced preferentially at the onset of impulsive emission. The X-ray flare emission lasts longer than the radio burst, as in normal flares. In at least one case, the propagation path of an energetic electron beam responsible for the metric emission agrees fairly well with a wisp-like feature seen in SXT images. The simple detection of type IIIs from flaring XBPs is interesting because it strengthens the association between XBP flares and normal flares, implying that the same physical process is involved in each.

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