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FLARES IN ACTIVE REGION NOAA 7260 - ROLE OF EMERGING FLUX

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Abstract

Active region NOAA 7260 exhibited remarkable flare activity as an emerging flux region appeared in the following part and evolved into the δ configuration. While it is difficult to associate an emerging bipole with a flare both temporally and spatially, there is an overall correlation of the total darkness integrated over of the sunspot area, as measured in the *Yohkoh*/SXT white-light images, with the soft X-ray flux and flare occurrence. It appears that the flares in the emerging flux region occurred preferentially at locations close to the spot of preceding polarity that emerged in the earliest evolution of the region.

1. Introduction

It is generally accepted that flare activity is likely to be enhanced where magnetic field is highly sheared (Hagyard *et al.* 1984), or new magnetic flux is emerging (Kurokawa 1991 and references therein). Active region NOAA 7260 (hereafter AR 7260), whose central meridian transit was on 18 August 1992, showed both conditions and indeed produced many small-to- medium flares, the largest being M4.0 in GOES X-rays. The region consisted of a rapidly growing emerging flux region (EFR) embedded in a plage of the following polarity, and a large leading sunspot, which also produced some flares. In addition to hundreds of transient brightenings or microflares (Shimizu 1993), the Soft X-ray Telescope (SXT) on board the *Yohkoh* spacecraft observed about two dozens of flares above the GOES C 1 level.

In this paper we discuss an aspect of the relation of flux emergence with flares in the EFR of AR 7260. Leka *et al.* (1994a) has made as a comprehensive list of flux emergence in AR 7260 as one can achieve from a morphological study. Although we probably have to

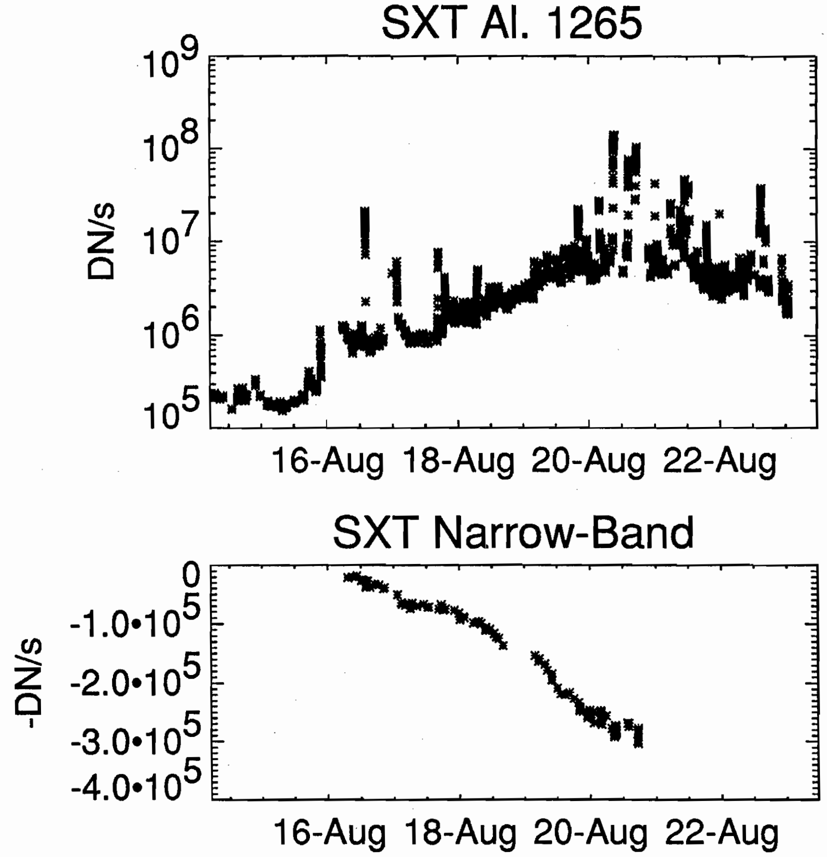

Fig. 1. (above): Time variation of the soft X-ray flux of the EFR in the thin aluminum (Al 1265 Å) filter, (below): Time variation of the total flux in the narrow-band filter below the average spot-free level.

resort ultimately to magnetograms to determine increase or decrease of magnetic flux, they are often seeing limited and those at different observatories are hard to compare. Alternatively, in spite of the lack of high resolution, the aspect telescope of *Yohkoh* SXT can provide seeing-free photometry in the optical range (Hudson 1994). In the following we analyze the images in the so-called narrow-band filter to obtain the integrated darkness over the spot area, which we regard as another measure of magnetic flux.

2. Optical Observations using SXT

AR 7260 was almost always selected as the target region of SXT, especially after 16 August 1992, thanks to the absence of brighter regions. This means a good time coverage of the data, enabling us to study not only flares but also the evolution of the region over several days.

In Fig. 1 we show how the X-ray flux from the EFR increased while the integrated darkness due to sunspots grew. In order to get the total darkness over the spot area, which changed with time, we first deproject the narrow- band images to eliminate the effect of foreshortening. After correcting for limb darkening, we obtain the average brightness of four

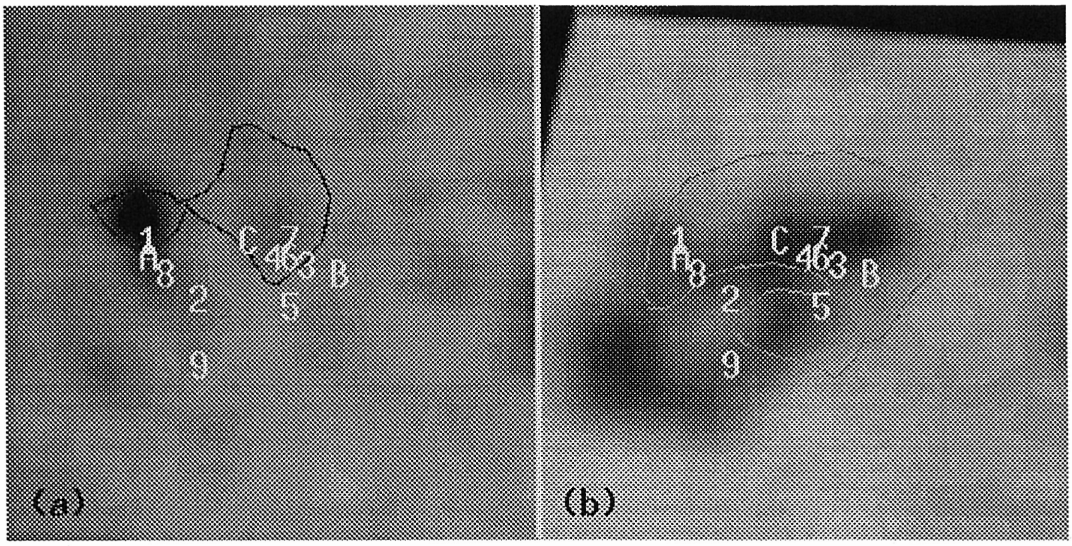

Fig. 2. SXT narrow-band images at (a) 16 August 1992 13:55 UT and (b) 20 August 1992 17:23 UT, overplotted with the locations of the flares. Flares occurred in order of 1,..,9,A,B,C.

spot-free areas. Then we sum up the flux in short of the average in those pixels with counts less than 95 as umbras. As the region approaches the limb, contaminations due to damages of the CCD become indistinguishable from real solar features, limiting the analysis to the period before 21 August 1992.

Although we are still awaiting a good method of flat-fielding the SXT optical images to eliminate unwanted non-solar effects, Fig. 1 suggests that the rate of flux emergence is not uniform over time, and that major flares correspond to the periods of mild growth of the region whereas the X-ray flux gradually increases during rapid growths of the region. Looking at pixel-to-pixel time profiles on shorter time scales, however, we sometimes see a sudden increase in darkness of some spots in association with a flare, some of which appear in small amplitudes in Fig. 1. This is discussed in more detail in Nitta *et al.* (1994).

3. Locations of the Flares in the EFR

SXT observed a total of 12 flares > C1 in the EFR between 16 August and 23 August 1992. In Fig. 2 we plot the location of the brightest pixel of each flare on narrow-band images in the first and the sixth flare. For this plot, we deproject a narrow-band image from each flare and apply translational transformation so that the centroid of the large leading spot is fixed among them. The first X-ray image of the flare cube receives the same procedure as the corresponding narrow-band image. Of course, the position of X-ray emission thus obtained may not accurately represent the real position, because the deprojection procedure assumes zero height from the photosphere. However, early in a flare, the brightest soft X-ray emission often comes from a low altitude, and from a morphological point of view we infer that the loops involved in our flares are generally small and accordingly low.

Fig. 2 also shows position of photospheric polarity inversion lines, encircled regions being of preceding (negative) polarity. The EFR consisted of at least seven bipoles (Leka *et al.*, 1994a) forming a complicated group of delta configuration. It appears that more than a half of the flares were centered close to the location of the first short-lived p spot of the EFR seen in the western p island in Fig. 2(a), where the long-lived evolving p spot, which is seen in the eastern p island in Fig. 2(a), moved to by 20 August (Fig. 2(b)). The magnetic field along the inversion line, close to the highest concentration of flare occurrence, was highly sheared (Leka *et al.*, 1994b). Most flares in that area probably involved a small island of f polarity wedged in between the biggest two spots of p polarity. By late afternoon of 20 August, this small f polarity island was merged into the older spots of the same polarity in the southeast (Fig. 2(b)).

4. Discussion

There are various ways in which emerging flux is involved in a flare. The most straightforward idea is that a flare is due to interactions of the emerging bipole itself with pre-existing field, often resulting in dramatic reconfiguration of the field topology. However, Fig. 1 suggests that the flares may not occur while new flux is vigorously emerging. Indeed, most new bipoles in Leka *et al.* (1994a) are identified at times before a series of the flares here (except for the first one) took place. According to Nitta *et al.* (1994), in most of the flares plotted in Fig. 2, the loop(s) that brightened with the flare can be identified at least several hours prior to the flare and some of them persist in a similar pattern in flares that are several hours apart. In some flares the brightened loops represent pre-existing structures, becoming unstable probably because of emerging flux. In other flares, however, brightening appears to be compact, perhaps involving an emerging bipole. In the latter case, the similar emission pattern in the following flares suggests that magnetic flux has to be supplied to the bipole to compensate losses due to the flare.

Acknowledgment

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