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A Rapidly Evolving Active Region NOAA 8032 observed on April 15th, 1997

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Abstract. The active region NOAA 8032 of April 15, 1997 was observed to evolve rapidly. The GOES X-ray data showed a number of sub-flares and two C-class flares during the 8-9 hours of its evolution. The magnetic evolution of this region is studied to ascertain its role in flare production. Large changes were observed in magnetic field configuration due to the emergence of new magnetic flux regions (EFR). Most of the new emergence occured very close to the existing magnetic regions, which resulted in strong magnetic field gradients in this region. EFR driven reconnection of the field lines and subsequent flux cancellation might be the reason for the continuous occurrence of sub-flares and other related activities.

Key words.

1. Introduction

There are number of observations suggesting new flux emergence as the cause for the flare trigger. Association of frequent occurrence of flares with EFR was reported by Rust (1972) in a number of cases. Examples of EFR triggered flares have been also reported by Wang *et al.* (1991), where they observed X-class flares near the sites of EFR. Wang & Shi (1993) suggested that emergence of new flux and its cancellation with the existing flux is wholly inseparable, elementary process in the active region for the occurrence of flares. In this paper we have carried out a similar study of flux emergence, cancellation and their relation to the occurrence of flares for the active region NOAA 8032.

2. **Observations**

The region NOAA 8032 of April 15th, 1997 was observed to evolve rapidly in its magnetic and chromospheric structures. The Solar Geophysical Data (SGD) reported a number of B-class and two C-class flares during its 10 hours of evolution. The SOHO/EIT Fe IX/X 171 Å images showed loop formation and repeated brightening due to new emerging flux regions. At Udaipur Solar Observatory we have taken near simultaneous photospheric white light and magnetic field observations of this active region using the USO video magnetograph (Mathew *et al.* 1998). The active region

NOAA 8032 showed up in Ca I 6122 Å image as a group of small pores with opposite polarities, the leading spot had a negative polarity.

3. Discussion and results

Figure l(a) to (d) shows the contour plots of magnetograms, obtained on April 15, 1997 at 05:23, 08:26, 09:05 and 10:01 UT. The contour plots show clear evidence of EFRs and corresponding magnetic field changes in this active region. Major changes in the field occurred during the initial stages of evolution, i. e., within 3 to 4 hours after the begining of our observations at 05:20 UT. As evident in the contour plots most of the new fluxes emerged near to the existing flux regions, i.e., within 10-15 arc-seconds. According to SGD (May 1997, Number 633, Part I, GOES X-ray data) the flare activity at this region started around 07:30 UT. Even though the magnetogram data were not available at the time of flare, the images obtained around 08:26 UT shows a clear evidence of EFRs at the flaring site. It can be inferred that emergence of new flux regions had started before the first X-ray flare and perhaps triggered the flare. Similar observations of surges and Hα compact flares due to the rapid emergence have been reported by Kurokawa (1998).

We have analysed the changes in the positive and negative fluxes. Flux changes were calculated in two specific areas of EFRs marked by small boxes on Fig. 1 (b) and listed in Table 1. In the magnetograms taken around 05:23 UT, more positive flux was present as compared to that at 08:36 UT, which implies a reduction of flux imbalance. Later an increase and then again a decrease was observed in the net positive flux. This oscillation of the magnetic flux can perhaps be attributed to the continuous emergence and cancellation of fluxes during the flare activity.

This study revealed that EFRs evolved considerably when flare occurred. At this region flux change at a rate approximately 10^{13} Mx/s was found which conforms with earlier observations by Ribes (1969) and Rust (1972). At the location *b* of EFR the magnetic flux of negative polarity gradually increased while the positive polarity decreased. This observation was in agreement with Ribes results that the flare occurred when the magnetic flux in one feature is increasing and decreasing in another adjoining area. Magnetic field gradient is another important parameter to decide the flare location. We have carried out the magnetic field gradient calculation for the above active region for two specific locations and found an increase in magnetic field gradient during 05:23 to 10:01 UT. This strong horizontal gradient might have favored the continuous occurrence of sub-flares, surges and related activities in NOAA 8032.

Potential field calculation is carried out for this active region using Schmidt technique and observed flux distribution from USO VMGs. A comparison has been carried out between the calculated potential field and SOHO/EIT images. The calculated transverse field shows the photospheric or low lying connections while the EIT UV images shows higher loops as observed in the coronal heights. The loop structure initially showed simple bipolar nature of the active region. A number of new loops are noticed on further development of the active region, which corresponds to the emergence of new magnetic flux. Comparing the USO longitudinal magnetic maps and SOHO/EIT images, we find that the bright areas in SOHO/EIT images correspond to the location of EFRs or high magnetic field gradient. Due to the low resolution of EIT it is difficult to distinguish a particular loop which connects to

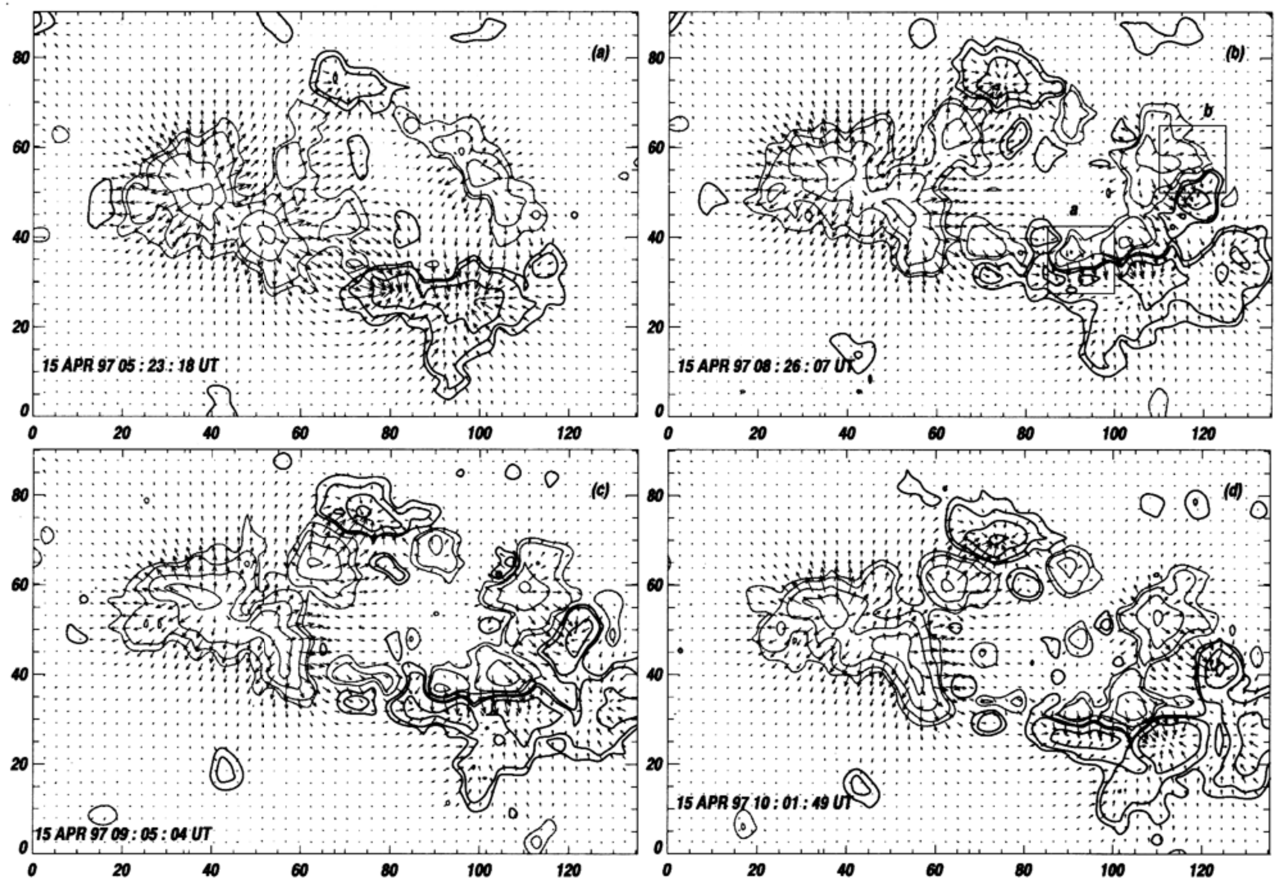

Figure 1. The evolution of active region NOAA 8032 for a time period of 05:23 UT to 10:01 UT. The contours (longitudinal field) are plotted at ±50, ±100, ±250, ±500, and ±750 G. Arrows indicate the calculated potential transverse field. The subscripts along x and y axes correspond to 10 arc-sec.

Table 1.

Location (a)

Flux in Maxwell	05 : 23 UT	08 : 26 UT	09 : 05 UT	10 : 01 UT
Positive flux	9.9×10^{16}	4.0×10^{17}	6.4×10^{17}	3.4×10^{17}
Negative flux	1.3×10^{18}	1.0×10^{18}	1.3×10^{18}	1.2×10^{18}

Location (b)

Flux in Maxwell	05 : 23 UT	08 : 26 UT	09 : 05 UT	10 : 01 UT
Positive flux	1.5×10^{18}	1.0×10^{18}	9.0×10^{17}	5.1×10^{17}
Negative flux	3.9×10^{16}	8.6×10^{17}	1.0×10^{18}	1.2×10^{18}

the opposite polarity near the locations of EFRs. This makes it difficult to obtain a measure of non-potentiality of the magnetic field structure using the loops. However it can be inferred that the system of loops connecting a simple bipolar structure evolved to a more complicated system as a result of new flux emergence in this region.

4. Conclusion

The GOES X-ray flare data showed a number of sub-flares and two C-class flares during the 89 hours of the evolution of NOAA 8032. Although no major flares were recorded in this region, continuous recurrence of sub-flares, surges, filament formation and re-orientation of structures were noticed. From the comparison of the magnetograms obtained around 05:23 UT and 08:20 UT, large changes were observed in magnetic field configuration. Due to the emergence of new magnetic flux, increase in magnetic field gradient and flux changes were observed throughout the evolution of this active region. The EFRs driven reconnection of field lines and the subsequent flux cancellation might be the reason for continuous occurrence of sub-flares and other related activities. The potential field calculation showed rearrangement of the field lines during the evolution of the active region. Similar loop formation and reorientation were also noticed in the transition region loops.

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