# EMERGING FLUX REGIONS AND SURGE ACTIVITIES IN NOAA 7270

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ABSTRACT

The evolutional characteristics of a rapidly growing active region NOAA 7270 was studied with high resolution H$\alpha$ filtergrams. At least six emerging flux regions are found to grow during a short period from 5 through 6 September, 1992. Most of flares and surges during this period were caused by these emerging flux regions and or the interactions between them. A special attention is given to the conspicuous surge activities observed at the leading edge of the preceding sunspot, where some parasitic magnetic flux of opposite polarity is found. We conclude that the surges were produced by the reconnection between the new emerging flux and the surrounding older magnetic fields.

## I. Introduction

The causal relations between flares and emerging flux regions have been pointed out by many optical observations, which are summarized in Kurokawa (1991). Kurokawa (1991) reached to a conclusion that the emergence of twisted magnetic flux rope is the most important factor for a major falre activity, and suggest that more detailed studies of the evolutional changes of the flare productive emerging flux regions are necessary, combined with high resolution H$\alpha$ images, magnetograms and X-ray images.

NOAA 7270 is one of such regions as to be studied in details, because it rapidly developed and produced many flares and surges from 5 through 7 September, 1992. Firstly, therefore, we study when and where emerging flux regions came up in the region and how they interacted with each other to build up the energy of the flares and surges.

Secondly we present the observational results of a conspicuous surge activity observed at the leading edge of the preceding sunspot in NOAA 7270 and discuss the causal relation between the surges and the emerging flux region.

## II. Emerging Flux Regions in NOAA 7270

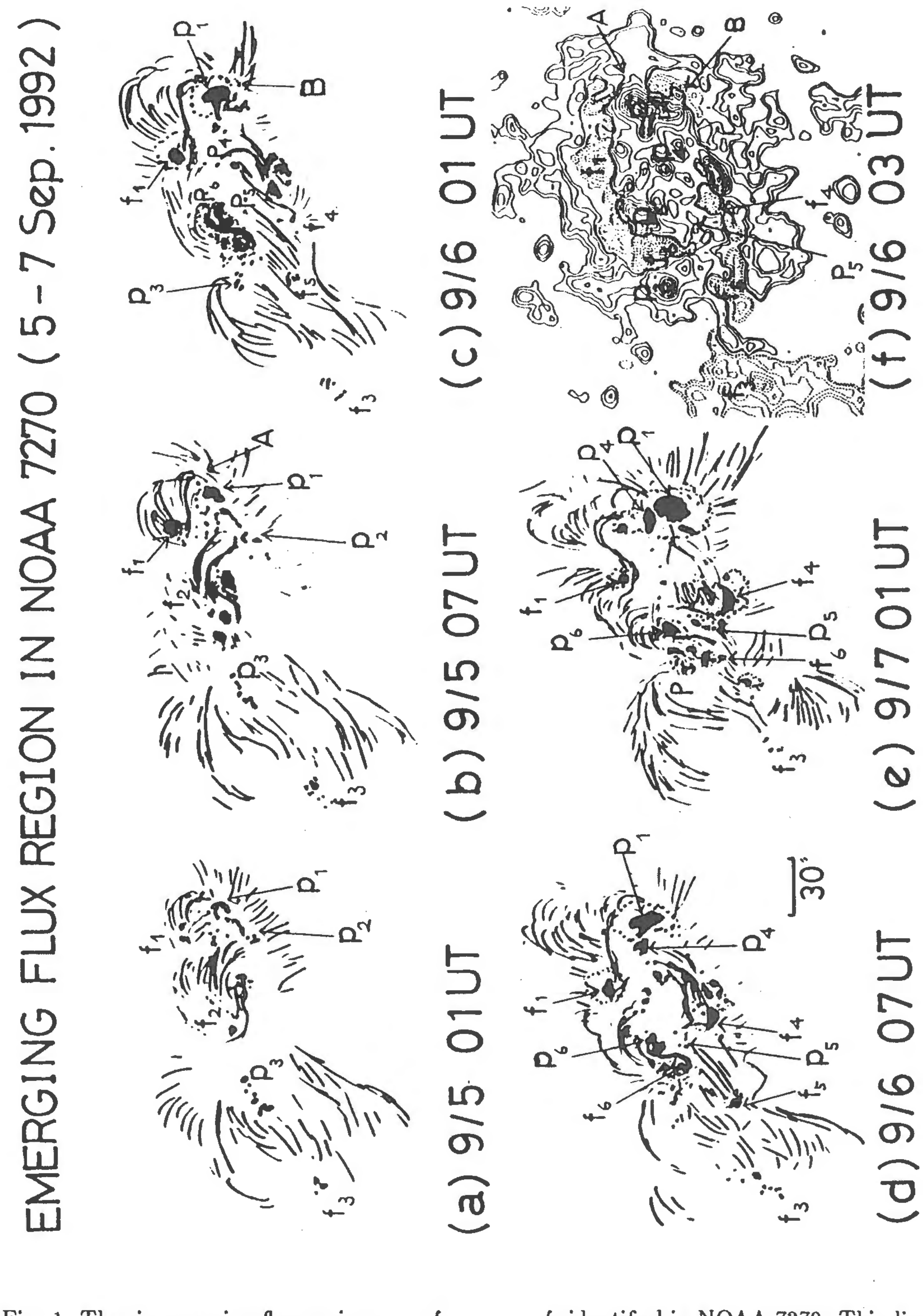


Fig. 1. The six emerging flux regions $p_1$ - $f_1$,.....,$p_6$ - $f_6$ identified in NOAA 7270. Thin lines are H$\alpha$ dark fibrils and filaments representing directions of the chromospheric transverse magnetic field. The dark spots, dots and dotted circles shows sunspot umbrae, pores and penumbrae, respectively.

High resolution H$\alpha$ images of NOAA 7270 are obtained from 5 through 7 September, 1992 with the Dmeless Solar Telescope ( DST ) at Hida Observatory, Kyoto University. Some of H$\alpha$ images showing the evolutional changes of the region are presented in Figure 1 of Kitai et al.(1994) in this proceedings. Examining them in details, we studied when and where emerging flux regions came up and how they interacted with each other to build up the flare energy.

Figure 1 shows the evolutional changes of H$\alpha$ dark fibril structures which present the direction of chromospheric transverse magnetic field. The sunspot umbra, pore and penumbra are shown by dark spots, dots and dotted circles, respectively. We found six newly-emerging bipolar pairs or emerging flux regions and marked $p_1$ - $f_1$, ....., $p_6$ - $f_6$ in Figure 1. the p (positive) and f (following) polarities are determined by comparing sunspot images with the longitudinal magnetic field maps observed by the Mitaka flare telescope of National Astronomical Observatory and the Huairou magnetograph of Beijing Astronomical Observatory.

From 01 UT through 07 UT of 5 September, three emerging flux regions $p_1$ - $f_1$, $p_2$ - $f_2$, $p_3$ - $f_3$ are found to be developing. Notice the rapid growth of the $p_1$ - $f_1$ pair and the development of sheared dark fibrils between them. Another remarkable is a drastic change in the direction of H$\alpha$ fibrils at the central part of NOAA 7270 between 07 UT of 5 September and 01 UT of 6 September. Note the new emergence of $p_4$ - $f_4$, $p_5$ - $f_5$ pairs whose axes are nearly perpendicular to that of the $p_2$ - $f_2$ pair in Figure 1 (b) and (c). The emerging flux pair $p_6$ - $f_6$ also showed a dratic change in its magnetic field structure. Notice a conspicuous growth and a big change in the direction of the neutral-line fibril between the $p_6$ - $f_6$ pair, or the development of the magnetic shear in Figure 1 (b) and (c).

These three active emerging flux regions were major sources of the flare activities observed in NOAA 7270 from 5 through 7 September.

## III. Surge Activity at the Edge of an Emerging Flux Region

Conspicuous H$\alpha$ surge activities were continuously observed at the leading edge of the preceding sunspot $p_1$ from 5 through 7 September. Examining the video images obtained with Flare Monitoring Telescope ( FMT ), which was recently installed at Hida Observatory, we determined the start, maximum and end times of each surge. The result is summarized in Table 1. We found the following characteristics of the surge activities: (1) Surges repeatedly spouted out from two locations A and B indicated in Figure 1 (b), (c) and (f) where Figure 1 (f) is a longitudinal magnetic field map observed by Huairou Station of Beijing Astronomical Observatory. The surge activities are especially strong at the location A on 5 September, and at the location B on 6 September. (2) The mean life time of the surges is about 15minutes. (3) The surges were repeatedly produced at the same location every about 25 minutes. Some examples of the surges observed with DST in H$\alpha$ line wing, are shown in Figure 2.

Table 1. List of Surges Observed with Flare Monitoring Telescope at Hida Observatory.

| DATE | TIM ( UT ) START | MAX | END | PHENOMENA (H α CENTER) | REGION AND NOTE |
|---|---|---|---|---|---|
| 9/4 | 23:19 | 23:24 | 23:30 | SURGE | leading edge of preceding spot: (A) |
| | 23:38 | 23:43 | 23:46 | SURGE | (A) |
| | 23:45 | 23:50 | 23:57 | FLARE | central part of the region |
| 9/5 | 00:01 | 00:05 | 00:10 | SURGE | (A) |
| | 00:12 | 00:15 | 00:35 | FLARE, SURGE | east edge of the region |
| | 00:41 | 00:45 | 00:55 | SURGE | (A) |
| | 01:05 | 01:08 | 01:22 | SURGE | leading edge of preceding spot: (B) |
| | 01:09 | 01:13 | 01:21 | SURGE | (A) |
| | 01:30 | 01:35 | 01:45 | SURGE | (B) |
| | 01:41 | 01:46 | 02:00 | SURGE | (A) |
| | 01:55 | 02:00 | 02:05 | SURGE | (B) |
| | 02:01 | 02:03 | 02:15 | SURGE | (A) |
| | 02:46 | 02:48 | 02:59 | SURGE | (B) |
| | 03:15 | 03:20 | 03:28 | SURGE | (B) |
| | 03:26 | 03:35 | 04:05 | SURGE | (A) |
| | 04:10 | 04:15 | 04:30 | SURGE | (A) |
| | 04:37 | 04:41 | 04:50 | SF, SURGE | (A) |
| | 05:02 | 05:07 | 05:38 | SF, SURGE | (A) |
| | 05:40 | 05:46 | 05:56 | SF, SURGE | (A) |
| | 06:07 | 06:11 | 06:20 | SF, SURGE | (A) |
| | 06:20 | 06:34 | 06:50 | SF | (A) |
| | 07:10 | 07:14 | 07:33 | SF | along the preceding edge |
| | 07:50 | | 07:58 | SURGE | (A) |
| 9/6 | 00:28 | 00:38 | 00:50 | SF, SURGE | (B) and (A) |
| | 00:55 | 01:05 | 01:15 | SURGE | (B) |
| | 01:16 | 01:22 | 01:32 | SURGE | (B) |
| | 01:40 | 01:46 | 01:51 | SURGE | (B) |
| | 01:58 | 02:01 | 02:20 | FLARE,SURGE | central part of the region |
| | 02:15 | | 02:30 | SURGE | (B) |
| | 02:22 | 02:28 | 02:45 | FLARE | along the leading edge of p spot |
| | 02:49 | 02:52 | 02:58 | BP, SURGE | (B) |
| | 02:58 | | 03:15 | BP, SURGE | (B), brightening at 03:01 and 03:08 |
| | 03:50 | 03:54 | 04:05 | BP, SURGE | (B) |
| | 04:09 | 04:11 | 04:25 | SUBFLARE(SF) | north-east part of the region |
| | 04:28 | 04:32 | 04:42 | SURGE | (A) |
| | 04:38 | 04:44 | 04:50 | SURGE | (B) |
| | 04:51 | | 05:10 | SURGE | (B) |
| | 05:13 | 05:18 | 05:30 | FLARE | (A) and north of (A) |
| | 05:27 | | 05:35 | SURGE | (B) |
| | 05:40 | 05:42 | 05:52 | SF | (A) |
| | 05:45 | 05:52 | 06:02 | SURGE | (A) |
| | 06:13 | | 06:20 | SURGE | (B) |
| | 06:34 | | 06:40 | SURGE | (A) |
| | 06:45 | 06:48 | 06:55 | SURGE | (A) |
| | 06:54 | 07:01 | 07:25 | FLARE | central part of the region |
| | 06:55 | | 07:15 | SURGE | (A) |
| | 22:55 | | 23:30 | SURGE | (B) |

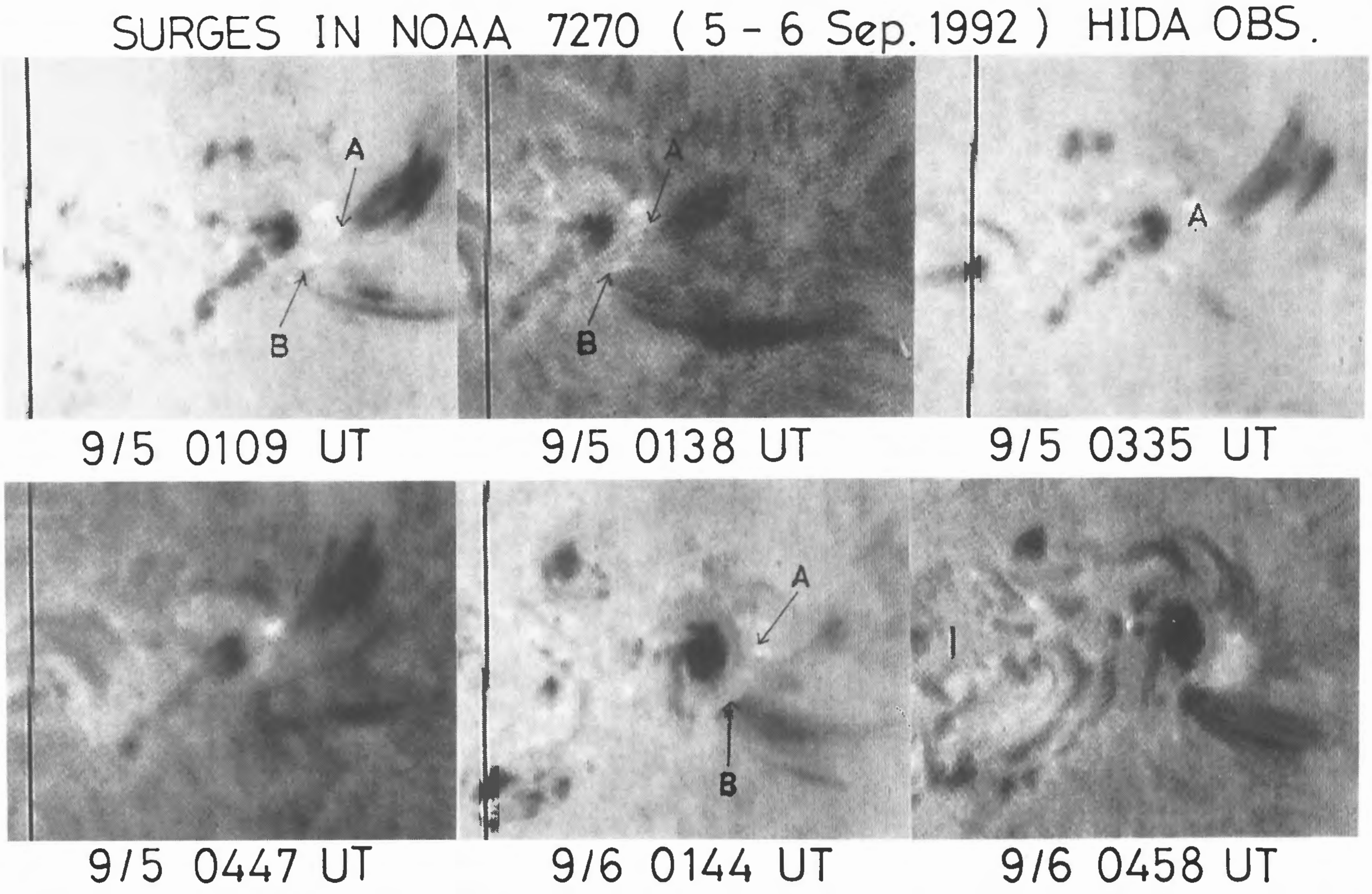


Fig. 2. Cntinous Surges Activities observed at the leading edge A and B of the preceding sunspot of NOAA 7270.

## IV. Discussion and Conclusion

Kurokawa (1988) found H$\alpha$ surges are often observed at the earliest stage of emerging flux regions (EFR), and Kurokawa and Kawai (1993) called them EFR-surges. They found that EFR-surges spout out from the site where emerging flux collides with pre-existing magnetic field of oppsite polarity, and concluded that the EFR-surges are produced by the magnetic field reconnection between the EFR and the surrounding region.

The $p_1$ - $f_1$ pair of NOAA 7270 is rapidly growing emerging flux region as studied in the section 2. The surrounding region of the $p_1$ spot has the same magnetic polarity as the $p_1$, and the surge activity described in the previous section may contradict the conclusion of Kurokawa and Kawai (1993). We can notice, however, some parasitic magnetic fields of following polarity around the location B in the Huairou magnetogram (Figure 1 (f)). In addition, the surge activities are nearly continuously observed simultaneously with the successive emergence or constant growth of the $p_1$ - $f_1$ pair. With these two evidences we cnclude that the conspicuous surge activities observed at the leading edge of NOAA 7270 are produced by the same reconnection process as proposed by Kurokawa and Kawai(1993). We suggest that the absence of any parasitic magnetic field of the following polarity at the location A in Figure 1 (f) is due to an insufficient resolution of the magnetogram.

## References

Kitai, R., Kurokawa, H., Funakoshi, Y., Nakai, Y., Ichimoto, K., Shibata, K., and Yaji, K. 1994, in this proceedings.

Kurokawa, H. 1988, Vistas in Astronomy, **31**, 67.

Kurokawa, H. 1991, Lecture Notes in Physics, **387**, 39.

Kurokawa, H. and Kawai, G. 1993 ASP Conference Series, **46**, 507.