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A Large Filament and Flares in Active Region NOAA 5669 on September 2, 1989

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Abstract. The behaviour of extended filaments in the vicinity of a new emerging magnetic flux site has been investigated during the 2N/M5.8 flare on September 1 and several flares on September 2, 1989.

1. Introduction

The behaviour of flare-associated filaments might be complex and the observational picture becomes complicated for different Doppler velocities along the filament channel. Filtergrams, obtained simultaneously in the center and wings of the H_α line up to $\lambda = H_\alpha \pm 3\AA$, permits us to better understand the filament behaviour and its relation with the flare situation in the active region (AR). The analysis of the evolution of extended filaments helps us to investigate large magnetic arches. In this paper we try to follow the behaviour of the long-lived large filament and filament-like structures in AR NOAA 5669 with a complex magnetic field on September 2, 1989 during the 2N/M5.8 flare and four consecutive subflares, one of which was accompanied by a M1.1-class X-ray burst.

2. Observations and Description of the AR

Observations were obtained at the High Altitude Station of Sternberg Astronomical Institute near Alma-Ata, Kazakhztan on a coude-refractor Opton using an H_α filter with a passband of 0.25 Å. We used also H_α filtergrams of the Meudon Observatory, photospheric (FeI 5324.19Å) and chromocpheric (H_β 4861.34Å) magnetograms, H_β Dopplergrams and H_β images, obtained at Huairou Solar Station (Table 1).

The AR NOAA 5669 was a large complex spot group stretching for about 30° from east to west. The leading spot, N1, had negative polarity and the following ones had mainly positive polarity, being surrounded by little spots and pores of both N and S polarities. The large-scale magnetic polarities interchanged as N-S-N-S-N-S. A schematic drawing of the AR (Figure 1a) is a result of the superposition of photos, obtained in red and blue wings of the H_α line, and H_β chromospheric magnetic charts, recorded at 0155 and 0239 UT (Zhang et al. 1992).

Comparing magnetograms (see Zhang et al. 1992) we notice that a good

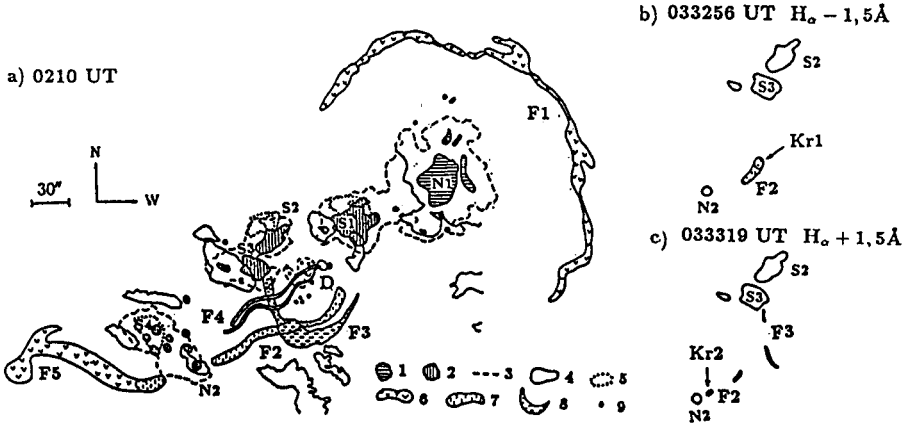

Figure 1. Drawings of events in AR5669: spots of N(1) and S(2) polarities, ($H_\alpha \pm 3Å$); penumbra (3); chromospheric fields of N(4) and S(5) polarities; filaments in center of H_α (6), in $H_\alpha - 0.75Å$ (7), in $H_\alpha + 0.75Å$ (8); little spots and pores (9).

similarity existed between the main magnetic features observed at the photospheric and chromospheric levels. Large-scale magnetic structures were relatively stable during several hours. Small-scale elements in the middle of the AR changed dynamically. Here in the vicinity of the D magnetic feature new emerging magnetic flux (EMF) was observed on September 2. Numerous little spots and pores were seen here on the H_α filtergrams, taken at $\lambda = H_\alpha \pm 3Å$ (Figure 1a). In this place the transverse magnetic field was noticeably sheared. Here at 2350 UT on September 1 the 2N/M5.8 flare occurred and for six hours after it H_α emission kernels of several subflares were located there. In the front the AR was encircled with a large quiet filament, F1, situated on the boundary of the large-scale magnetic field net. The F2 filament, having a length of about 3×10^5 km, was located beneath the AR along the boundary between the magnetic field regions of S and N polarities. The east end of F2 was near the N2 spot (Figure 1a). The loop-like H_α structure F3 was observed for several hours. It looked most striking at 0209:35 UT in $\lambda = H_\alpha + 0.75Å$. Later its intensity decreased and at 0530 UT it was not seen at all. In the middle of the AR filament-like structures, F4, were visible, located nearly parallel to the F2 filament and ending in the vicinity of the EMF near D. Behind the AR the large filament, F5, existed. One of its ends was anchored in the vicinity of the trailer spot group S4 (Figure 1a). The F2 filament was also observed in the H_β line but the F3 and F4 structures were not seen in the H_β line (Zhang et al. 1992).

3. Results and Discussion

The behaviour of the large H_α chromospheric features was investigated during several flares on September 2, 1989 and compared with the magnetic structures and Dopplergrams. The eastern parts of the H_β F2 filament, adjacent to the N2

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Table 1. Observational Data about NOAA 5669

Date	Magnetic field		Velocity field	H_β images	H_α filtergram (Alma-Ata)	Events in AR (SGD)
	photosph.	chromosph.				
	Zhang et al. 1992					
1.IX				2250		
1.IX			2351	2354		2350-2502
2.IX	0002	0042	0032	0025		2N/M5.8
2.IX	0107	0154		0154	0150 0208-0210	0141-0156 SF/M1.1 0153-0227 SID
2.IX		0238	0235	0238		0231-0242 SF
2.IX		0300			0309-0315	H_α-brightening
2.IX	0335	0338	0325	0333	0330-0336	0330-0345 SN
2.IX	0544	0534	0527	0530	0524-0536	0522-0546 SF

spot, were seen during the preflare phase, maximum and decay of the 2N/M5.8 flare on September 1, 1989 and were not observed in the vicinity of the flare site (Zhang et al. 1992). The large S-shaped F5 filament, located just behind the AR, had a similar behaviour (Porfir'eva and Yakunina 1995). It became active when flares occurred near the filament end in the vicinity of the singularity pivot-point, situated near the S4 spot group (Figure 1a). This pivot point in the AR was found by Mouradian and Soru-Escout (1991).

During the five hours after 0100 UT, the F2 filament was observed along its whole channel length both in the H_β line and the H_α line. Comparison of the H_α filtergrams with the H_β images has shown that there was a good match between the contours of the H_α and H_β F2 filament. The sites with the maximum H_α intensities corresponded to the places with the maximum H_β intensities. The H_α F2 filament was active during the observations (see Table 2, for the wavelengths of maximum intensities of the filaments). The topology of Doppler velocities

Table 2. Events in the AR NOAA 5669 on September 2, 1989.

Universal time	Data about flares (SGD)	Filament F2	Loop structure F3	Filament F4	Flare locations
0208-0210	0154 M1.1 0153-0227 SID	$H_\alpha - 0.5Å$	$H_\alpha + 0.75Å$, $H_\alpha + 1Å$;	$H_\alpha - 0.5Å$	Emission kernels in
0309-0315	H_α-brightening	$H_\alpha - 0.75Å$; Kr1 in $H_\alpha - 1.5Å$ in east part of F2, Kr2 in $H_\alpha + 0.75Å$ near the spot S5	$H_\alpha + 0.75Å$; vestiges in $H_\alpha + 1Å$	Hα, $H_\alpha - 0.75Å$	back part of the AR and in
0330-0336	0330-0334-0345 SN 21S, 54E	$H_\alpha - 0.75Å$; Kr1 in $H_\alpha - 1.5Å$ in east part of F2, Kr2 in $H_\alpha + 0.75Å$ near the spot S5	$H_\alpha + 0.75Å$; vestiges in $H_\alpha + 1.5Å$	H_α, $H_\alpha - 0.75Å$	region of emergent magnetic
0534-0536	0522-0524-0546 SN 18S, 48E	$H_\alpha - 0.5Å$; Kr1 in Hα-1Å in east part of F2		Hα-0.5Å	flux near D

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along F2 was complex and changeable. A correlation between H_α filtergrams and H_β Dopplergrams existed. Preferential blue Doppler shifts were registered along the H_β filament at 0235, 0325 and 0527 UT. Before a subflare at 0330 UT red Doppler shifts were observed in F2 near the N2 spot (Zhang et al, 1992). The filament looked more intensive in the blue H_α wings, and it was seen along its whole length in $\lambda = H_\alpha - 1\AA$, which agrees in general with the H_β velocity. The maximum Doppler velocity was in kernel Kr 1 (Figure 1b, Table 2). At 0309–0336 UT a little site Kr 2, seen in the red wing of the H_α line from $\lambda = H_\alpha + 0.75\AA$ to $\lambda = H_\alpha + 2\AA$, existed near the N2 spot. Hence, we conclude that both in the H_α filtergrams and H_β Dopplergrams, red Doppler shifts existed in the eastern part of F2. At the same time blue shifts dominated the western parts of F2 (Figure 1b, c, Table 2).

Distinct filament-like structures P1, P2 and T are noticeable on the chromospheric magnetic charts at 0154 and 0534 UT (Zhang et al. 1992). The magnetic structures P1 and T coincided by their location with the eastern and western parts of the F2 filament. The third structure P2 is possible to compare with the H_α features F4 (Figure 1a). As was indicated by Zhang et al. (1992), the appearance of the magnetic structures P1, P2 and T likely reflected the magnetic field configuration inside the filaments F2 and F4.

The AR looked active when sudden ionospheric disturbances (Table 1) were observed. A distinctive feature in the AR was the large loop-like structure F3, having a shape of a flag in $\lambda = H_\alpha + 0.75\AA$ (Figure 1a). A leg was anchored in the S3 spot. The F3 feature remained visible until 0335 UT. This magnetic feature possibly existed before 0200 UT and was visible in the H_β flare.

4. Summary

The behaviour of the large filaments in the vicinity of the EMF in the middle of AR 5669 was analysed during several hours after the 2N/M5.8 flare on September 1, 1989 (2350 UT). The filaments were active during the entire time of the observations and had Doppler velocities equal to dozens of km s^{-1}. The contours of the H_α and H_β F2 filament and their locations were similar. A definite correlation between H_α Doppler shifts in the F2 filament and H_β Dopplergrams existed. The observed activation could be explained by a gradual decay of the 2N/M5.8 flare, accompanied by several subflares. The investigated filaments were long-lived features. The H_α Meudon filtergrams show that the filaments F2 and F3 stayed visible all during the AR's passage across the solar disk.

References

Mouradian Z. and Soru-Escout I. 1991, in Dynamics of Solar Flares, B. Schmieder and E. Priest (eds.), Observ. de Paris, DASOP, p. 139

Porfir'eva G.A. and Yakunina G.V. 1995, Izvestia Academia Nauk., 59, 181

Zhang H., Ai G., Li W. and Chen J. 1992, Sol. Phys., 146, 61