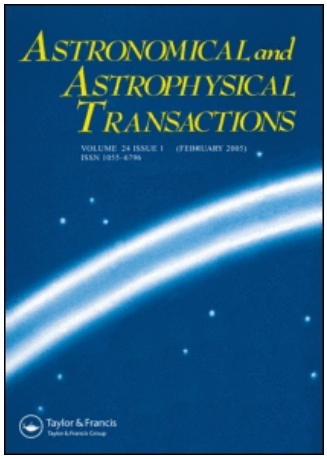

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

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Online Publication Date: 01 October 2001
To cite this Article: Porfir'Eva, G. and Yakunina, G. (2001) 'Extended long-lived filaments and active region magnetic fields', Astronomical & Astrophysical Transactions, 20:3, 539 - 542
To link to this article: DOI: 10.1080/10556790108213595
URL: http://dx.doi.org/10.1080/10556790108213595

Astronomical and Astrophysical Transactions, 2001, Vol. 20, pp. 539–542
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EXTENDED LONG-LIVED FILAMENTS AND ACTIVE REGION MAGNETIC FIELDS

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(Received October 11, 2000)

The evolution of large filaments in active region (AR) NOAA 5669 was investigated during the AR passage across the solar disk in September 1989. The filament behaviour was found to correlate with the flare location.

KEY WORDS Sun, flares, filament, magnetic fields

Many flares have been observed to be associated with preflare activization of neutral line filaments and their subsequent disappearance or exhaustion. In other cases, filament eruptions occur simultaneously with or during the flares. Sometimes a filament is found to remain without a change throughout the flare and activizes in consequence of the flare development. Investigations of the behaviour of the filament features and its evolution help us to understand magnetic field topology in the vicinity of the filament and its role in flare processes. In this paper we investigate the fate of the large long-lived filaments, existing in AR NOAA 5669 and its environment from September 1 to 9 of 1989. During the September period, 68 X-ray flares and 176 Hα ones were fixed in the AR.

Sequences of filtergrams taken over the Hα-line center and its wings up to H$\alpha \pm 3$ Å were obtained at the High Altitude Station of the Sternberg Institute near Alma-Ata on an Opton coude-refractor using an Hα-filter with a passband of 0.25 Å. We also used Hα and K_{IV} of CaII K spectroheliograms of the Meudon observatory, and magnetograms and Hβ images, registered at the Huairou Solar Station.

The AR was a large complex spot group, stretching over about 30° from east to west. A schematic drawing of the AR on September 2 is shown on Figure 1. The drawing is a result of the superposition of the photos, obtained in the red and blue wings of the Hα-line and Hβ chromospheric magnetic charts (Zhang *et al.*, 1993). 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.

From the front the AR was encircled by a large quiet filament F1, situated on the boundary of the large-scale magnetic field net. The filament F2, having a length

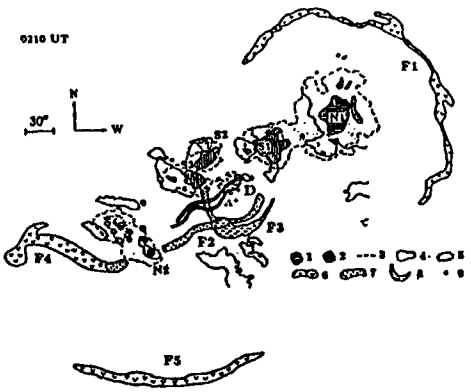

Figure 1 Schematic drawing of the AR NOAA 5669 on 2 September, 1989: spots of N (1) and S (2) polarities, H$\alpha \pm 3$ Å); penumbra (3), chromospheric fields of N (4) and S (5) polarities by (Zhang *et al.*, 1993); filaments in the center of the Hα line (6), in H$\alpha - 0.75$ Å (7) and in H$\alpha + 0.75$ Å (8); little spots and pores (9).

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 loop-like Hα structure F3 was observed over several hours on September 2. It looked most striking at 0210 UT in the red Hα wings. Behind the AR the large filament F4 was observed. Under the AR the large filament F5 existed, connected by thin threads with the filament F1, clearly visible on the best photos. The behaviour of the filaments and the relation with the flare situation in the AR was investigated.

The filaments F1 and F5 were relatively quiet and existed during all the AR disk passage. Only separate pieces of the filaments exhibited activization and became visible in the Hα wings. Each of these filaments was distinctly seen as a whole in the center of the Hα line. The filaments F2, F3 and F4 showed activity and were often observed in the Hα wings. The behaviour of these filaments correlated with the flare situation in the AR (Porfir'eva and Yakunina, 1995; Porfir'eva *et al.*, 1998a). The long filament F4 behind the AR existed over all the time of the observations. On September 8 its length was more than 2×10^5 km (Figure 2*b*). One end of the filament was anchored in the vicinity of the tail spots of the AR. Its appearance and behaviour were changeable. Sometimes it seemed to be almost quiet but usually it had Doppler shifts. It was observed 13 times from September 2 to 8 of 1989. The filament was found to be almost quiet when flares or flare-like brightenings occurred near the middle of the AR area (4 cases) and active when flares occurred near the rooted filament end (9 cases). Examples are seen in Figure 2.

The behaviour of the large filaments F2 and F3 was investigated over several hours after the 2N/M5.8 flare occurred on September 1, 1989 (2350-2502 UT) in the vicinity of a new emerging magnetic flux (EMF) site in the middle of the AR near the magnetic structure D. Large-scale magnetic structures were relatively stable, but small-scale elements in the middle of the AR changed dynamically. Numerous little spots and pores were seen here (Figure 1) and the transverse magnetic field was

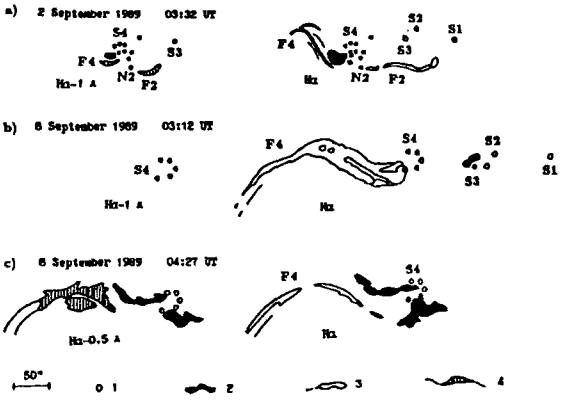

Figure 2 The events observed in the AR NOAA 5669 in September, 1989. The filaments were revealed to be almost quiet when flares or flare-like brightenings were situated near the middle of the area (*b*) and active when flares occurred near the rooted filament ends (*a*, *c*). 1, spots; 2, flare; 3, Hα-filament; 4, blue filament.

noticeably sheared (Zhang *et al.*, 1993). The eastern parts of the Hβ F2 filament, adjacent to the N2 spot, were seen during the preflare, maximum and decay phases of the 2N/M5.8 flare on September 1, 1989, and western filament parts near the flare site were not observed (Zhang *et al.*, 1993). Later the F2 filament was observed along its whole length in the center of both the Hα and Hβ lines. Separate pieces of the F2 filament showed Doppler velocities up to H$\alpha \pm 1$ Å. We can say that the F2 and F4 filaments had similar behaviour. The pieces of them adjacent to flare sites were active and showed noticeable Doppler velocities. This can be seen distinctly in Figure 2*a*.

An impressive feature in the AR was the loop-like structure F3 (Figure 1). It was very noticeable in the red wing of the Hα line ($\lambda = \text{H}\alpha + 0.75$ Å) at 0210 UT on 2 September, having the shape of a flag. The foot of one of its legs was anchored at the spot S3. Sudden ionospheric disturbances were observed at this moment (0153–0227 UT, SGD). The F3 feature remained visible till 0335 UT on September 2 but by 0309 UT it had become very weak.

It was interesting to understand how these large filaments changed their shapes. To compare images, registered on different days, from September 1 to 9 of 1989, a correction for the perspective effect was made and transformed images a superimposed Carrington coordinate system were used (Porfir'eva *et al.*, 1998b).

The large filaments F1 and F5 preserved their shapes but their positions moved a little to the west. Their fate seems to depend on the motions of large-scale magnetic fields.

Flares accompanied by X-ray radiation were often located in middle and tail parts of the AR, where the filaments F2, F3 and F4 were situated. The filament F2 was strong from September 1 to 6, then it weakened and became scarcely visible on 7, 8, 9 September. It was active and changeable but its position was relatively

stable. The large S-shaped filament F4, located just behind the AR, was found to preserve its general contours in spite of its activity (Porfir'eva *et al.*, 1998b).

The loop-like structure F3 (Figure 1) was very massive in $\lambda = H\alpha + 0.75$ Å at 0210 UT on 2 September, when sudden ionospheric disturbances were observed. This large arch was not seen at all on the next day, however on September 4 it was observed. Later from September 5 to 8 large absorption arches were seen with their eastern legs ending near the spot S3 and the west ends, located between the spots S1 and N1 (Porfir'eva *et al.*, 1998b). So extended magnetic structures, in the shape of large loops, seem to exist for several days in the AR, connecting the middle and leading spots. A similar AFS (arch filament system) was seen on 1 September on Meudon filtergrams in $\lambda = H\alpha \pm 0.5$ Å. The behaviour of this AFS was very dynamic. Massive arches were seen, when some matter was ejected from solar surface along the magnetic force lines, otherwise the loops were not visible, although the magnetic field was preserved.

Thus, the behaviour of extended long-lived filaments with lengths of about $(1.5–3)\times10^5$ km was followed in NOAA 5669 in September 1989. Almost all large filament structures existing in the AR preserved their positions and shapes in general features, changing them in details. The filaments F1 and F5, bordering the AR, were relatively quiet. Other large filaments were constantly active and their separate volumes adjacent to the flare site had Doppler velocities of dozens of km s^{-1}. Interactions between dynamical small-scale magnetic features and relatively stable large scale magnetic structures seem to be one of the causes of solar activity in the AR but such interactions did not strongly disrupt the overlying magnetic field in high layers of the Solar atmosphere. The main magnetic structures were preserved for many days in spite of numerous flares.

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