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A CASE OF FILAMENT – ACTIVE REGION INTERACTION

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Abstract. We analyze a huge filament observed between 5 and 19 September 2001. In its evolution it is linked to the active region 9612, observed between 7 and 16 September 2001. The filament has a strange morphology and dynamics: starting as two parallel components (A and B), it becomes a double sigmoid filament when a third component (C) appears linking the other two. An unusual magnetic topology characterizes this evolution: the active region is located between the parallel components. When the third component becomes observable, it links these ones first below the active region. After a spectacular plasma movement registered in filament (A), this one becomes linked to (B) above the active region. In spite of these dramatically changes of the magnetic topology and filament – active region switch, no CME is observed. Only a few flares occurring in AR9612 are registered and these ones can be seen in the dynamics of the filament as an expression of large scale magnetic reconnections.

1. INTRODUCTION

Solar prominences formation on the opposite magnetic polarity inversion line gives us information about solar magnetic field. Filaments and prominences are real tracers of the magnetic topology on the Sun. The neutral magnetic field lines naturally appear: (1) inside bipolar active regions, (2) between active regions and (3) between active regions zone and the unipolar solar magnetic field. These neutral lines change their topology in time and indicate plasma interaction with the magnetic field.

We analyzed a filament observed between 5 and 19 September 2001 that interacted with the active region NOOA 9612, interchanging their position on the solar disk and so configuring a new magnetic topology in few days. The active region NOAA 9612 is observed between 7 and 16 September 2001, developing few flares. We could distinguish more steps during the filament evolution as for as the relative position of the filament and the active region. We notice also the special shape of the filament at a some moment during its evolution - it gets a double sigmoid shape.

We have used ground based observational data (BBSO, Meudon, Mauna Loa) and also space data provided by SOHO.

2. CORONAL SIGNATURES

The Hα filament was registered on the solar disk between 5 and 19 September 2001. This filament has three components designing a double sigmoid shape. Fig. 1 displays these parts: component A was observed in Hα between 5 and 18 September 2001 with a sigmoid shape. Component B observed between 6 and 19 September, form another sigmoid together with component C. The last one appeared very clearly between 10 and 11 September, above the AR9612, but the filament channel is visible in Hα under AR9612, on 8 and 9 September 2001 (Fig. 1).

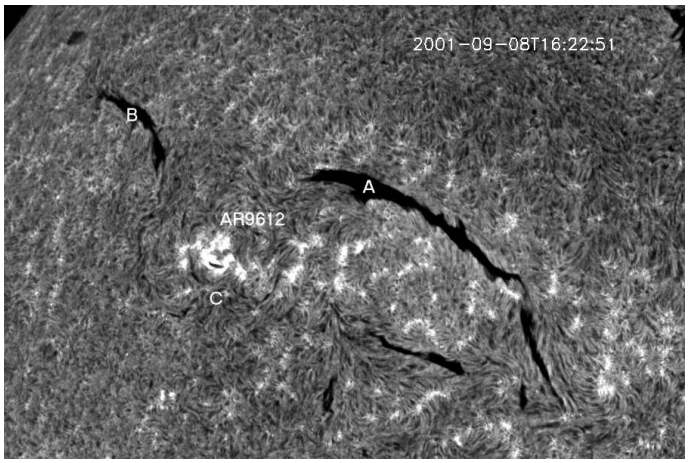

Figure 1: The components of the Hα filament, denoted A, B and C, and AR9612. Filament C, more thin than the other two, is here located at the bottom of AR9612 and has a curved shape, like a decumbent "3".

All these components jointed in a big complex filament A+B+C, where the filament C disappeared at a moment and B and A jointed again, reforming a complex filament above AR9612. This fact implies large scale changes of the magnetic topology since a filament channel interchange its position with an active region. In Fig. 2 left we see first the filament C appeared in South of AR9612 on 8 September 2001. The complex filament A+B shifted above the active region after a plasma movement in filament A, on 8 and 9 September 2001. This change of topology could be seen in more detail on Fig. 2, where the filament C channel jumped above the active region on 8 September or filament B elongated, between 19 and 22 UT.

On 8 September 2001, during these magnetic reconnections, the EIT/SOHO and H α images reveal strong and spectacular plasma flows inside the filament A. Fig. 3 displays these plasma flows as observed by EIT. If we look at EIT running differences movie we can see in detail these plasma flows inside the filament A, flows that started from AR9612. First, loops oscillation occurred in AR9612 and a bright surge on the disk rose at 18:24 UT. Beginning with 20:24 UT large plasma movement took place in the filament A from the middle to the end foot-points of the filament. Coronal loops seemed to link to filament C over AR9612 and, after few hours of filaments activation, some loops opened, released some matter at 5:45 UT on 9 September 2001,

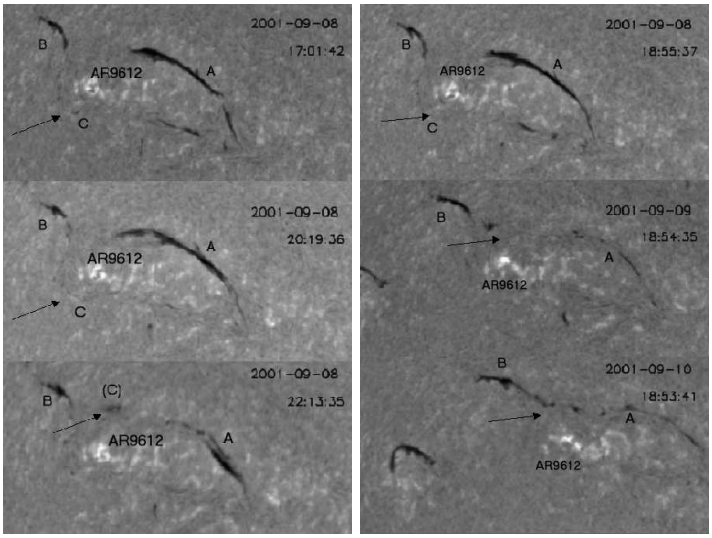

Figure 2: Hα evolution of the filaments and AR9612 position. The arrows indicate filament C channel and than the point of A+B junction.

and reconnect back with filament B, above the AR9612 (Fig. 4). On 9 September, at 5:09 UT, a small dimming is observable in the active region zone indicating mass ejection in that area. Probable the CME was too small to be reported by CDAW CMES Catalogue.

After this event took place, a new magnetic configuration appeared, a huge complex filament formed above AR9612 by joint of components A and B most probably, while the component C disappeared.

3. MAGNETIC FIELD EVOLUTION

In order to understand the reported behavior of a complex filament (A+B+C) interacting with the active region 9612, we must pay attention to the magnetic field changes in photosphere. Characterizing the filaments type, we note that components A and B are formed between active regions. The filament C is formed inside AR9612. This is an important aspect and one of the causes that all the complex A+B+C was not stable and changed quickly in a more stable configuration.

We have analyzed the MDI magnetograms and detected magnetic flux emergence in AR9612. Fig. 5 displays the trace of the complex filament channel in two different days, before and after the large scale magnetic reconnections, i.e. on 8 and on 9 September 2001. In the first configuration, the filament has a double S shape that cross the active region. Emergence of magnetic flux in AR9612 broke the sigmoid and made filament C disappear.

Using a non-liner force free field 3D extrapolation code, we computed the coronal magnetic field lines from the MDI magnetograms in the filament and active region zone. Fig. 6 plots these computations at different moments near the time of plasma movements and magnetic reconnections between the double sigmoid filament and the

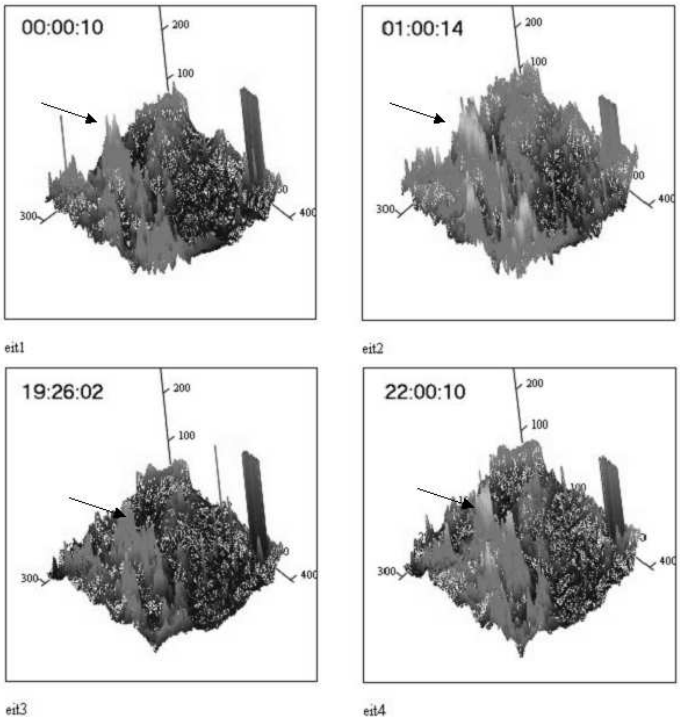

Figure 3: A 3D filament A (indicated by arrows) activation during plasma flows derived from EIT observations on January 8, 2001. These flows produced mainly from top to the footpoints.

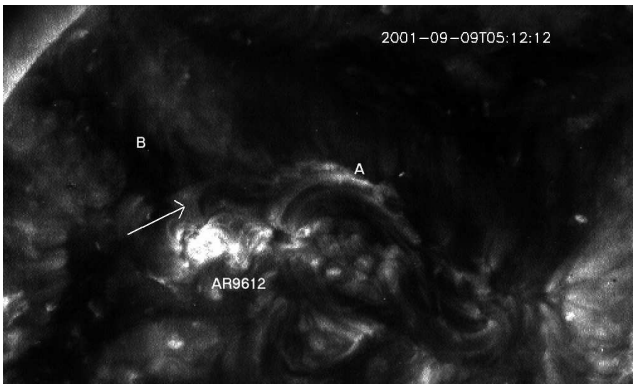

Figure 4: EIT/SOHO image in 195 A line, at 5:12 UT, when magnetic loops open and later reconnect to make A and B filaments junction

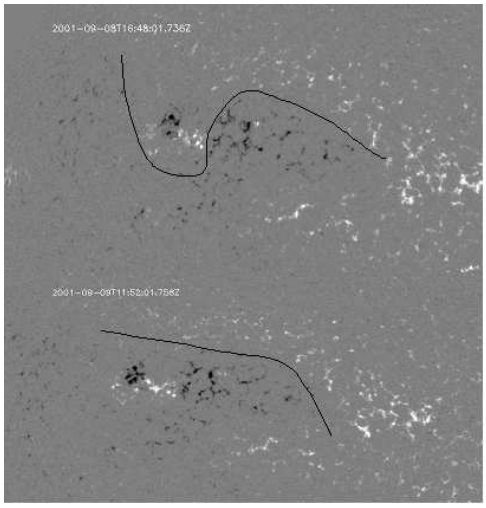

Figure 5: MDI magnetograms and the complex filament channel

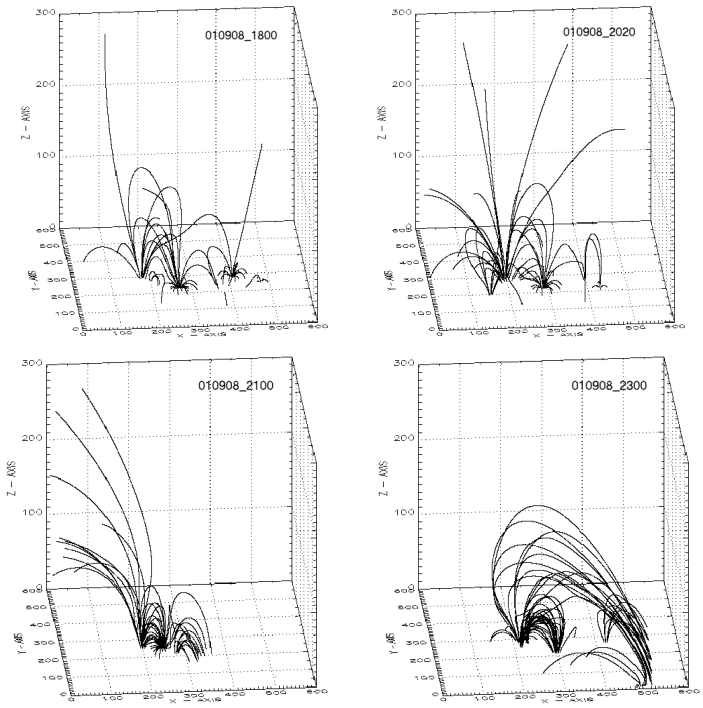

Figure 6: Coronal magnetic field extrapolation from MDI magnetograms at different moments

active region. We can see a very strong dynamics of the magnetic field lines during few hours. At a moment, some magnetic field lines opened indicating that plasma was ejected in that place. A mass ejection was observed in the coronal EIT observations. These 3D plots reveal strong magnetic reconnections in zone and support our remark made after the coronal observational data examination.

We note that no solar flare was reported in the active region zone during that magnetic reconnections.

4. CONCLUSIONS

We reported here an unusual case of large scale magnetic reconnections when a complex filament, composed by three parts, interchanged its position on the solar disk with an active region. These dramatic changes in the magnetic topology of an entire zone were not accompanied by solar flares.

On the EIT 195 A images we were able to detect a small coronal mass ejection, which is the most probable the filament C disappearance. This conclusion is supported by the aspect of the coronal magnetic field lines extrapolated from the MDI magnetograms.

After this important magnetic topology change, the filament became a polar huge filament and AR9612 developed giving few flares next days.

Acknowledgments

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