SURGES AND FILAMENTS IN ACTIVE REGIONS DURING SOHO CAMPAIGNS

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ABSTRACT

JOP 33 is a SOHO Joint Observing Program, in collaboration with Yohkoh and ground based observatories (GBO’s), dedicated to observe jets and their signatures in the transition region with CDS and SUMER and in the chromosphere by GBO’s. CDS observations provide large (4’ x 4’) and small (2’ x 2’) rasters in several diagnostic lines. JOP 17 has been adapted to observe dynamical events through the atmosphere, from the chromosphere to the corona, covering a large field of view (240” x 240”) and in 6 lines with CDS; while spectral observations in Lyman or N V lines with a high cadence are provided by SUMER.

During runs of these programs we observed a surge and a flare in active region (AR) 7968 on June 9, 1996, and bright faculae, surges, a filament and CDS bright knots in AR 8048 from June 3 to 5, 1997. From these observations, and from MDI data, we have been able to understand some of the responses of the coronal and chromospheric plasma to the evolution of the photospheric magnetic field in these regions. Emerging flux in an AR led to the formation of arch filament systems in the chromosphere, hot loops in the transition region and some hotter knots and X-ray loops in the corona as observed by SXT.

Frequent surges have been observed related to parasitic or mixed polarities, but coronal jets have not yet been found. Their lack of detection could be the result of the low density in the jet plasma as mentioned by Schmieder et al. (1995).

Key words: surges, UV and X-ray loops, filaments

Surges are commonly observed in restructuring fields when flux emerges inside active regions (ARs). Mixed magnetic polarities are present at the surge basis (Schmieder et al. 1983, 1993). Emerging flux may have other signatures: flares, arch filament systems in the chromospheric plasma (Alissandrakis et al. 1990, Mein et al. 1996, van Driel-Gesztelyi et al. 1996), UV bright loops (Rovira et al. 1998), bright X-ray loops (Malherbe et al. 1998), and jets (Shibata et al. 1992b, Canfield et al. 1996). These phenomena are explained by reconnection of emerging magnetic flux with pre-existing coronal field lines (Shibata et al. 1992 a).

We outlined systematic programs to track such flux emergence in ARs during coordinated campaigns, in 1996 and 1997, with SOHO and Yohkoh spacecrafts and ground based observatories (GBO’s). We present here observations of two ARs, AR 7968 observed in June 1996 and AR 8048 observed in June 1997.

For both regions we have magnetic data from SOHO MDI, Hα data from GBO’s, UV and coronal images from SOHO EIT and X-ray images from Yohkoh SXT. A Joint Observing Program (JOP 33) for the SOHO instruments, SUMER and CDS, was specially dedicated to this study and was running in June 1997. Besides, JOP 17 was also used for detecting dynamical events.

We conclude that, surges and jets are observed in these ARs during flux emergence, when a larger deviation from the potential field is present.

The larger data sets come from GBO’s:

1. filtergrams obtained at Bialkow (Poland) with an


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Figure 1. Evolution of spots and longitudinal magnetic field in AR 7968 (Huairou) from June 5, 1996 (top panels) to June 10, 1996 (bottom panels).

Figure 2. An arch filament system observed in the Hα line (Bialkow) and X-ray loops (Yohkoh) in AR 7968 on June 6, 1996, from 06:52:24 UT to 15:00:10 UT.
Figure 3. Hot loops observed by EIT and a surge observed on June 9, 1996 in AR 7968 (Bialkov).

Figure 4. Extrapolation of the magnetic field observed by MDI in AR 7968 for potential (left panel) and force-free field approximations with a constant alpha (right panel). The spatial scale is in Mm.

2. Instruments

SOHO MDI observations consist of full disk longitudinal magnetograms with a cadence of 96 minutes. SOHO EIT images were recorded once a day in the 4 usual wavelengths: He II 304 Å, Fe IX-Fe X 171 Å, Fe XII 195 Å, and Fe XV 284 Å. Yohkoh SXT observed these regions under a normal program in full disk images with no high cadence.

SOHO CDS ran JOP 33 in June 1997. This program is designed to use a small field-of-view (2' × 2') with two phases:

1. a survey of the region in 8 wavelength windows: 346.80 Å (Fe XII, Fe XIII, Si X), He I 584.33 Å, O V 629.73 Å, Mg IX 368.96 Å, Si X 356.00 Å, Fe XII 338.26 Å, Si XII 520.67 Å.

2. a series of 16 diagnostic lines in order to derive physical parameters: the doublet of Mg V, Mg VI, Mg VII, Mg VIII, Ne IV, Ne V, Ne VI, the doublet of Si X, Si XII, Ca X, O IV. The program planned for SUMER could not be achieved because the position of the ARs was not reachable by the slit.
Ho filter of 0.5 Å provide a good survey of the 2 ARs during their disk passage,

2. Magnetograms and white light images were recorded at Huairou observatory (China) during June 1996.

3. Velocity and intensity images in Hα line were obtained by using the Multi-Channel Subtractive Double Pass spectrographs (MSDP) at Bialkow and at Pic du Midi in 1996. These instruments provide simultaneous data in nine channels where the same region is recorded in nine wavelength ranges covering the Hα profile (Mein 1977). The Hα profiles are reconstructed for each pixel of the region. By searching the bicection position of the profile and the minimum intensity, maps of Dopplershifts and of intensity fluctuations are obtained.

4. White light images were obtained in Debrecen for June 1996 region.

3. AR 7968

AR 7968 appears on June 3, 1996, entering its decaying phase by June 10 (the magnetic flux becomes weaker) and dying 5 days after. A round negative spot forms inside a bipolar facular region on June 3, 1996. Between June 5 and June 6 constant emergence of flux is observed at the central portion of the AR (Fig. 1). The magnetic inversion line, which is perpendicular to the solar equator on June 4, becomes nearly parallel to it on June 6 and 7, coming back to its initial position by June 8. The main changes observed after this are due to the growth of parasitic polarities at the South of the following spot during June 9. The AR central meridian passage occurs on June 6, being located at N02 in its transit through the disk. During this whole period (June 5 to 9) we have observed arch filament systems and dark fibrils anchored in bright zones in the middle of the AR (Fig. 2) in Hα, while bright loops in UV lines and X-rays overlay the region in EIT and SXT images (Fig. 3).

On June 9 we observed a surge at 06:42 UT and a small flare at 09:06 UT. We have found no jet associated with the surge. In fact, the SXT image was taken before the surge ejection so that can be one reason; the second one is that generally jet densities are low (10⁹ cm⁻³) and, therefore, they are difficult to detect in an AR (Schmieder et al. 1995). The AR magnetic field is close to a potential configuration if we compare computed field lines with EIT and SXT loops. The extrapolation using a linear force-free approach shows that a good fit is obtained with α = 0 or 0.006 Mm⁻¹ on June 9 (Fig. 4).

On the other hand, MSDP observations show a surge with blue and red Dopplershifts along its axis suggesting the presence of small scale twist in the flux tubes.

We conclude that in this newly formed region, the large scale configuration contains no electric currents.

Surges and jets are not able to occur during the first phase of its evolution. Later, when mixed polarities appear at the South of the following spot, the configuration changes. Some twisted flux tubes are observed indicating that the potentiality is locally lost. The energy is released during reconnection of magnetic field as ejection of matter (surges).

4. AR 8048

AR 8048 was mainly stable in the sense that the flux stayed constant but its area was increasing, which is a sign that the AR is in its decaying phase (van Driel-Gesztelyi 1998). Following the evolution of the magnetic field, we find three interesting zones which could be places suitable for ejections. Around the leading spot a moat region is evolving. Such a region is generally related to surge and X-ray jet activity (Canfield et al. 1996). The moat region consists of bipolar elements moving radially away from the spot. The outer edge of the moat cell has the same negative polarity as the sunspot. When the leading cells of positive polarity reach the boundary they merge and disappear (Fig. 5).

In the middle of the AR we observe some dark fibrils in Hα line and bright X-ray loops with mainly bright footpoints (see EIT, CDS and Yohkoh images, Fig. 7). This is the signature of emerging flux at the centre of the AR. The bright knot is observed in transition region emission (e.g. OV at 2.5 × 10⁸ K). This OV footpoint shows variations in intensity of about 30%. We derive an electron density for the knot of 10⁶ cm⁻³ by using the ratio of O IV lines. The ratio of spectral lines from neon and magnesium ions indicates photospheric abundances in the more diffuse structures. This variation of elemental abundances has been observed in other active regions (Young and Mason 1997) and provides strong evidence for the emergence of magnetic flux.

At the South-East of the main bipole another pre-existing bipole region with some faculae is present. The interaction of these 2 bipole leads to the formation of a filament. According to Low (1996), this can occur between two ARs when they belong to the same subphotospheric flux tube. When they emerge in the middle of 2 Ω structures, dense material rises horizontally forming filamentary structures (Fig. 6).

Apparently the field in these three zones is potential and they do not show any jets, only some surge-like events around the following spot on June 5.

5. Conclusion

Observing two similar ARs we have found many characteristics that are related to the appearance of surges and jets:
1. Emerging flux in the middle of the ARs (magnetograms from Huairou and SOHO MDI, moat region around the leading spot)
2. Chromospheric arch filament systems,
3. Bright loops in UV (EIT, CDS aboard SOHO) and X-rays (Yohkoh).

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Figure 5. Magnetic field map of AR 8048 (MDI)

Figure 6. Filament formation at the South-East of AR 8048 (Bialkow)
These two ARs showed a nearly potential configuration, so we conclude that we observe surges only when:
1. Parasitic polarities or mixed polarities are visible close to the following spots
2. Twisted flux tubes or shear are present, the potentiality of the region is not preserved at small scales.

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Figure 7. CDS bright loops in the middle of the AR 8048

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