Moving Magnetic Features and associated events from chromosphere to corona (proposal for THEMIS/MSDP observations in 2004)

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PI: Etienne Pariat (LESIA)
Co-I: Brigitte Schmieder, Pierre Mein, Nicole Mein, Ludwig Klein, Gérard Trottet, Arkadiusz Berlicki, van Driel-Gesztelyi Lidia

Scientific Objectives of Observing time

1. Moving Magnetic Features (MMFs) in emerging active region Young Active Regions and new emerging magnetic flux produce MMFs associated with Ellerman Bombs (EBs). The models with Omega-shape magnetic lines are commonly accepted (Arch Filament Systems, coronal loops). However, the balloon Flare Genesis Experiment launched in 2000 over the Antarctica pointed out that the flux does not emerge with such shape of loops, but more as fragmented elements with more or less horizontal field lines (Pariat et al, 2004).

Hα profiles indicate different features at different levels:

- Line center: Arch Filament Systems
- Wings: the models proposed to interpret dopplershifts of AFS are still uncertain: rising up of loops or Bald Patches (field lines tangent to the photosphere, noted BPs). Hα surges are also associated with EBs and parasitic polarities (Rust 1968, Kurokawa and Kawai 1993, Asai et al. 2001).
- Far wings: emission excess called Ellerman bombs, with short lifetimes (20mn) and small areas (1 arcsec)(Georgoulis et al, 2002). Are they due to bombardments of the low chromosphere by energetic particles (Hénoux et al 1998)? Pariat et al (2004) used extrapolation techniques in linear force-free field approximation and explained the EBs by reconnections at the loci of BPs.

2. Moving magnetic features in decaying active regions

Frequently the decay of active region is correlated with the expel of moving magnetic features (MMFs). They were named moving magnetic features by Harvey and Harvey (1973). They consist of small magnetic dipoles surrounding commonly the trailing sunspot. They cancel as they reach opposite polarities (Deng et al 2002). These MMFs are also correlated with Hα surges. The morphological and evolutionary characteristics support their physical origin , i.e., magnetic reconnection between the MMF and the pre-existing coronal fields (Kurokawa and Kitai 1993)

3. Energetic electron acceleration associated with MMFs

It is well known that particles are accelerated to high, sometimes relativistic, energies during solar flares. However, radio observations at metre and longer wavelengths have been showing distinct signatures of electron acceleration in the absence of flares, too. E.g. long lasting (several hours to days) noise storms and short type III bursts, produced respectively by electrons confined in coronal loops and by electron beams released into open magnetic flux tubes, are frequently observed in complex active regions. Type III emitting electron beams are closely related to jets of cold material (surges) observed in Hα (Chiuderi Drago et al. 1986) and to hot jets seen in X-rays (Raulin et al. 1996, Klein 1998, and references therein). Radio noise storms show that electron acceleration may persist in active regions during several days (Kai et al. 1985), but also that the acceleration procedes in a similar way as during flares (Raulin et al. 1991, Raulin & Klein 1994). Combining magnetography and coronal imaging by SoHO and TRACE with radio imaging of the noise storm emission with the Nançay Radioheliograph during three days, Bentley et al. (2000) suggested that the onset of a noise storm is related to the cancellation of small-scale magnetic features in the photosphere, and developed a scenario of magnetic reconnection. No Hα observations were available in this study.

The question of how non-flaring active regions accelerate electrons, under which conditions they are trapped in coronal structures, and how they may escape to the high corona and the interplanetary space remains a poorly studied problem. On the one hand, detailed multiwavelength observations as those of Bentley et al. are rare, and, as far as noise storms are concerned, even unique. On the other hand the lack of detailed Hα imaging and spectroscopy prevented us from identifying the nature of many transient features in the TRACE images, which judging from their morphology might have been either jets or emerging loops. We therefore propose to tackle the problem with more complete observational diagnostics. This could not be done during the phase of maximum activity because of the ubiquity of flares. But it needs active regions. The present phase of the descending activity cycle therefore appears most appropriate.

Method of observations

We plan to investigate Active Regions in the framework of both topics, according to the activity present on the solar disk. We propose a set of instruments which should provide accurate data in case of MMFs and associated dynamical events: measurements of magnetic fields and velocity fields with high spatial resolution, coordinated with Radio and EUV data. The proposal requires the combination of different instruments:

- Magnetography of the photosphere with THEMIS/MSDP and SoHO/MDI, from which the coronal magnetic field will be extrapolated. In case of possible change of modes MSDP to

TMR during the campaign, the transverse magnetic field will confirm the horizontality of the field lines in the BP regions.

- Hα (Ca II) spectroscopic imaging with the Meudon/MSDP (THEMIS/MSDP) which will allow us to identify systematic motions such as jets and emerging loops in the low solar atmosphere, and discriminate between jets and emerging loops,
- EUV spectro imaging with SOHO/CDS and EUV cornal imager TRACE (high spatial resolution)
- Coronal imaging with the Nançay Radioheliograph (NRH), which takes images at five frequencies in the range 450 MHz to 150 MHz (wavelengths 67 cm - 2 m). This emission comes from coronal sources between roughly 0.1 and 0.5 $R_\odot$ above the photosphere. The field of view covers the whole Sun, and the cadence is 8 images/second/frequency, with arcminute spatial resolution. The NRH carries out daily observations of the Sun.

Besides these dedicated instruments, imaging spectroscopy at hard X-rays with RHESSI will be used to trace low energy (several keV) nonthermal electrons in the low solar atmosphere, and the electron detector and radio wave experiment aboard the Wind spacecraft will be used to trace the escape of electrons to the high corona - though decametric-to-kilometric type III emission - and to time the arrival of electrons at the spacecraft. Although there is no guarantee that during the allotted observing time a major electron event will be detected by the particle instruments aboard Wind, this equipment will allow us to have a detailed view of unprecedented complementarity on electron acceleration in the non-flaring corona.

Observing time for the campaign

one week in 2004
(This time could be allocated before or after the time allocated to the proposal on *Filament Channel and EUV filament* of B.Schmieder (PI))

Coordinated instruments

1. **THEMIS mode MSDP** Na I D1 5896 and 8542 CaII (IV or IQUV) simultaneously,
2. **THEMIS mode MTR** (if the change to the mode MTR is possible one or two times during the campaign) lines 6302 FeI, 5896 Na I and 8542 CaII or 6562 Hα with the grid, slit= 1 arc sec, step=0.1 arc sec , with 1 camera.
3. **Solar tower of Meudon /MSDP** Hα line intensity
4. **NRH:** 2D-imaging of radio bursts (169 to 408 MHz)
5. **TRACE:** coronal loops at 171 Å and evolution of EBs at 1600 Å.
6. **CDS:** JOP 157 with sequences of SIG and ARCDIAG 1 ot 2

7. **MDI:** full active region magnetic maps for coronal extrapolation. It is suitable that the AR is close to the central meridian and in the high resolution sqare of MDI.

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