Mem. S.A.It. Vol. 78, 191

Memorie della

New results and future perspectives of THEMIS

B. Schmieder

Observatoire de Paris, section de Meudon, LESIA, UMR 8109 (CNRS), F-92195 Meudon Cedex, France
e-mail: Brigitte.Schmieder@obspm.fr

Abstract. We reported on scientific results obtained during the run of two Joint Observing Programs in 2003, 2004 concerning "New emergence flux and active regions " (JOP157), "Filaments and their environment" (JOP178) and preliminary results of more recent campaigns. Results concerning filament support show the capability of THEMIS/MTR to detect weak magnetic polarities and measure the vector magnetic field curvature. Tangent magnetic field lines to the solar surface were found at the feet of filaments and also in Hα+/-0.35 Å bright points close to penumbra. The bright points would be not due to high magnetic field concentration (1 KG) but to magnetic reconnection. The stability of filaments could be due to the existence of constant flux in its corridor where overlying arcades are anchored.
The comparison between THEMIS/MSDP and MDI shows the gain that we get. THEMIS is well adapted for measurements of weak field, the noise is much reduce compared to other instruments. For future campaigns we recommand to use alternatively the two modes: MSDP and MTR.

Key words. magnetic fields, filaments, magnetic reconnection

1. Introduction

THEMIS is a polarization-free telescope working in different modes, spectroscopic (MSDP) and spectro-polarimetric (MTR). It is operating since 1999.

I will present some recent results obtained during campaigns of observations involving the THEMIS telescope and space instruments (SOHO, TRACE, RHESSI). Two Joint Observing Programs were running during one week for each program in 2003, 2004, 2005, 2006: the JOP 157 on "New emergence flux and active regions ", the JOP178 on "Filaments and their environment". In 2003 and 2006, B.Schmieder was the PI of both JOPs. In 2004 and 2005, E.Pariat was the PI of JOP 157 and T. Roudier this of JOP 178. The 2005 and 2006 data are in the reduction process.

Send offprint requests to: B. Schmieder

2. Characteristics of THEMIS Observations

During these campaigns the THEMIS telescope was operating alternatively in two modes each day: the MSDP mode and the MTR mode (Mein 2002, López et al 2006). The MSDP was observing simultaneously with two CCD cameras in Hα and Na D1 lines or sequentially in Ca II 8542 Å and in Na D1. Large active regions (300 "$\times$ 150") were scanned in 15 to 20 minutes. Longitudinal magnetic field is com-

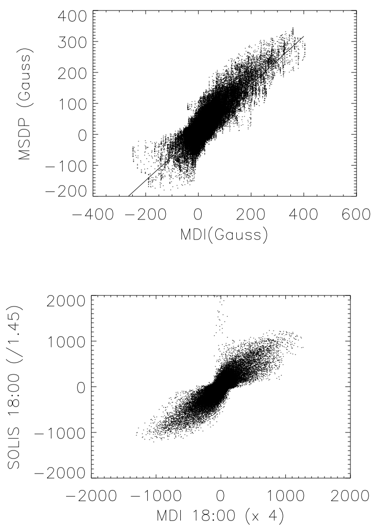

Fig. 1. Cross-correlation (*top panel*) between THEMIS/MSDP and MDI, (*bottom panel*) between SOLIS and MDI. The magnetic field of SOLIS is larger than this of MDI by a factor 4.

puted in the Na D1 line. The MTR mode allows us to obtain the magnetic field vector in multi-lines. For these JOPs we observed preferentially in Fe I 6301, 6302 Å and in Hα scanning a region of 300" x 150" in 1.5 hours. It was demonstrated that the calibration of THEMIS data in Na was comparable with MDI (Berlicki et al. 2006). Relatively good linear cross-correlation is found between the longitudinal magnetic field observed in Na DI ± 0.3 Å with the MSDP and in Ni with MDI in the range [-400, 400 Gauss] (Fig. 1). Cross-correlations were achieved between magntograms obtained by THEMIS/MTR, SOLIS and MDI. SOLIS magnetic field was larger than MDI values by a factor 4 (Fig. 1)! Fine structures of weak magnetic field of a few Gauss are well observed with THEMIS but just detectable with the two other instruments (Schmieder et al 2006a). They are lost in the noise of MDI and smeared in the SOLIS images (Fig. 2).

The observations of 2003 and 2004 are reported in more than ten refereed papers:

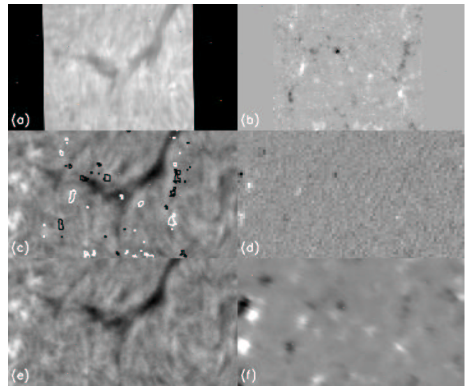

Fig. 2. Hα filament observed with (a) THEMIS/MTR, (c) and (e) BBSO and the corresponding photospheric magnetic field of (b) THEMIS/MTR, (d) MDI and (f) SOLIS. Polarities are saturated to 20 Gauss (Schmieder et al 2006).

– the calibration and the cross correlation with other magnetograms (Berlicki et al. 2006, Schmieder et al. 2006 a).
– filaments magnetic support and formation (López Ariste et al. 2006, Schmieder et al. 2006a, Dudik et al. 2007, Rondi et al. 2007).
– for flares, the thermal and non-thermal aspects and the evaporation mechanism have been studied from coordinated instruments (RHESSI, SOHO/CDS, THEMIS, TRACE) (Li Hui et al. 2006, DelZanna et al. 2006, 2007, Schmieder et al. 2006b).
– The U loops during magnetic emergence (Pariat et al. 2007).

I will report on some results concerning the filaments, the U loops and conclude on preliminary analyses of our last campaign in 2006 and the possible modes of observations for the next campaign in 2007.

3. Filament magnetic support

Solar prominences consist of long and thin sheets of cool chromospheric-like plasma which extend high above the photosphere in the diluated corona. This dense plasma is coupled with highly stressed magnetic field which

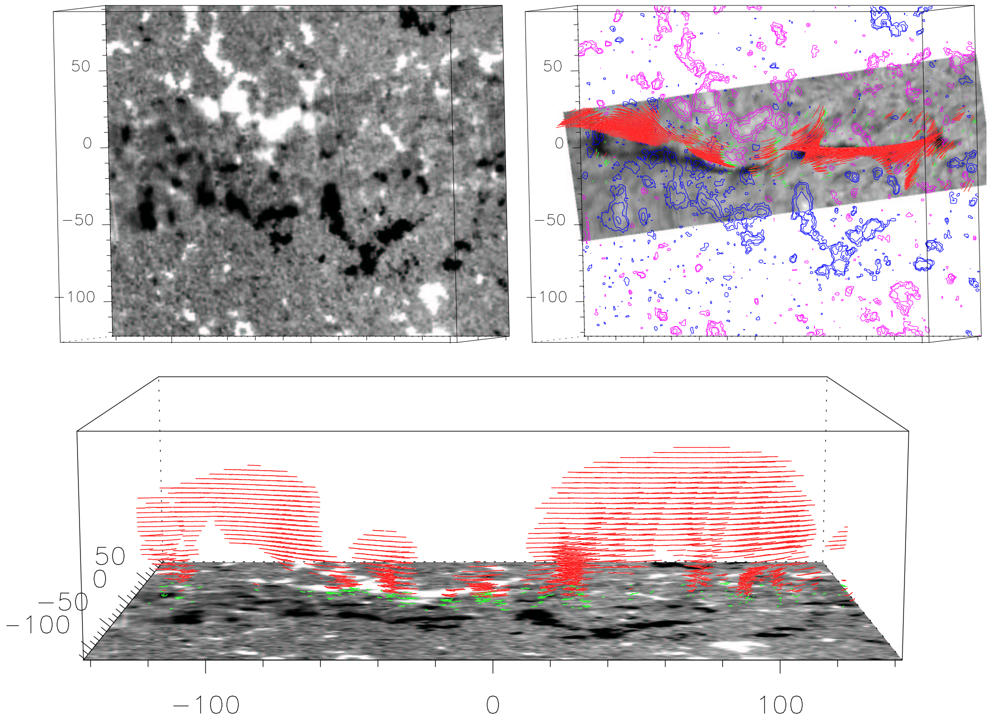

Fig. 3. *Top left*: Magnetogram used in the model consisting of coaligned SOHO/MDI and THEMIS/MTR magnetograms. The magnetogram is saturated to values of B_z = +- 40G in order that the smaller, parasitic polarities are visible better. *Top right*: Halpha picture of the filament, as observed by THEMIS/MTR. *Bottom panel*: 3D view of the extrapolation magnetic field lines. Only dips are represented where plasma can condense.

plays a role as support. Different magnetic models have tentatively been proposed which satisfy the MHD equations. Observations of the photospheric magnetic field - the longitudinal field if a linear-force-free approach is used, the vector field in case of non linear-force-free extrapolation- as boundaries conditions. The models should reproduce observational properties: structural i.e; the Hα observations, and quantitative i.e the measurements of B by Leroy (1978) or Bommier et al. (1994).

Very sucessful modeling have been achieved by many groups since the pionner work of Aulanier and Démoulin (1998). They are all based on the existence of a flux tube embedded in the corona and assumed that the cool plasma is supported in the dipped field lines of the tubes. On October 6 and 7, 2004, a large filament was observed by more than 10 instruments through the JOP 178. The observations are reported in Rondi et al. (2007). Dudik et al (2007) applied the linear-force-free model of Démoulin et al. (1997) using the MTR magnetogram embedded in a larger MDI magnetogram as boundary condition. He succeeded to reproduce the observed Hα filament with its fine structures and its barbs (Figure 3).

The main body consists of two flux tubes. A particular study has been performed regarding the barbs. Long field lines are involved and the Hα barbs are located above the dips

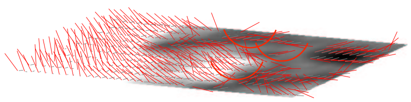

Fig. 4. 3D view of the magnetic vectors in a barb region. The black/white image represents the longitudinal magnetic field. The vectors are tangent to the photosphere along the magnetic inversion line (López et al. 2006).

of these field lines (Figure 3) and not rooted in minor polarities as the Engvold's group claimed (Lin et al. 2005).

Such a prominence modeling was confirmed by the observations of the magnetic field vector with THEMIS/MTR. López et al. (2006) showed that many small bipolar regions are located in filament channels. The 180 degree ambiguity has been resolved by using the chirality rules of filaments. The vectors indicated that loop-shape magnetic field lines are the ends of filaments while dipsof field lines are in barb regions (Figure 4). This observational result supports completely the MHD models.

4. Emerging regions

During the JOP 157, emerging flux has been identified in the active region NOAA 10655 on August 3, 2004 by the presence of Arch Filament Systems (Pariat et al. 2007). The MSDP observed the region in Ca II and Na D1 lines. The differential profiles of Ca II 8542 Å line obtained by subtracting the profiles of bright points with the neighboring ones show enhanced bright peaks in the wings of the line (+/- 0.35 Å). These profiles are typical profiles of Ellerman bombs. This is confirmed with the MTR observations in Hα. The EBs are lying over magnetic inversion lines of longitudinal magnetic field and coincide with bipolar magnetic polarities. The magnetic field vector is oriented along the axis of bipoles showing that the two polarities are connected by U loops if we consider the general trend of the active region which has the reversed sign of the bipole. This study confirms previous work done using Flare Genesis Experiment data (Pariat et al. 2004). Other studies concerning the 2005 campaign are in preparation.

5. Bright points

The campaign of 2006 has shown the existence of Hα wing bright points close to sunspot penumbra. The vectors are more or less horizontal in these points showing that the bright points are not due to high concentrated magnetic flux tubes. The active region NOAA 10905 was observed during a few days. At the periphery of the penumbra of the main spot of the active region small bright points were observed in the wings of Hα images. Nothing comparable is observed in the Hα center. We analyse the magnetic field vectors at the location of these bright points. We notice that they are located above a magnetic field inversion line, the vectors are more or less horizontal (Bommier, private communication).

6. Filament Disappearance

In August 2006, we have followed a large quiescent filament with THEMIS, TRACE and Hida Observatory Domeless Solar telescope (DST). The global filament structure was rising during one day to more than 100 000 km high before the disappearance of the filament (Fig. 6). It did not erupt but was submitted to high dynamics, particularly to counterstreaming flows in fine threads (Fig. 5). As the filament was rising, material was falling at both ends with velocities estimated to be of the order of 10 km/s (not comparable with free fall velocities like in post-flare loops 150 km/s). During three days the magnetic flux of the network, where the overlying arcades of the filament are anchored were decreasing from Fmax = 400 G to 100 G. We conclude that the rising

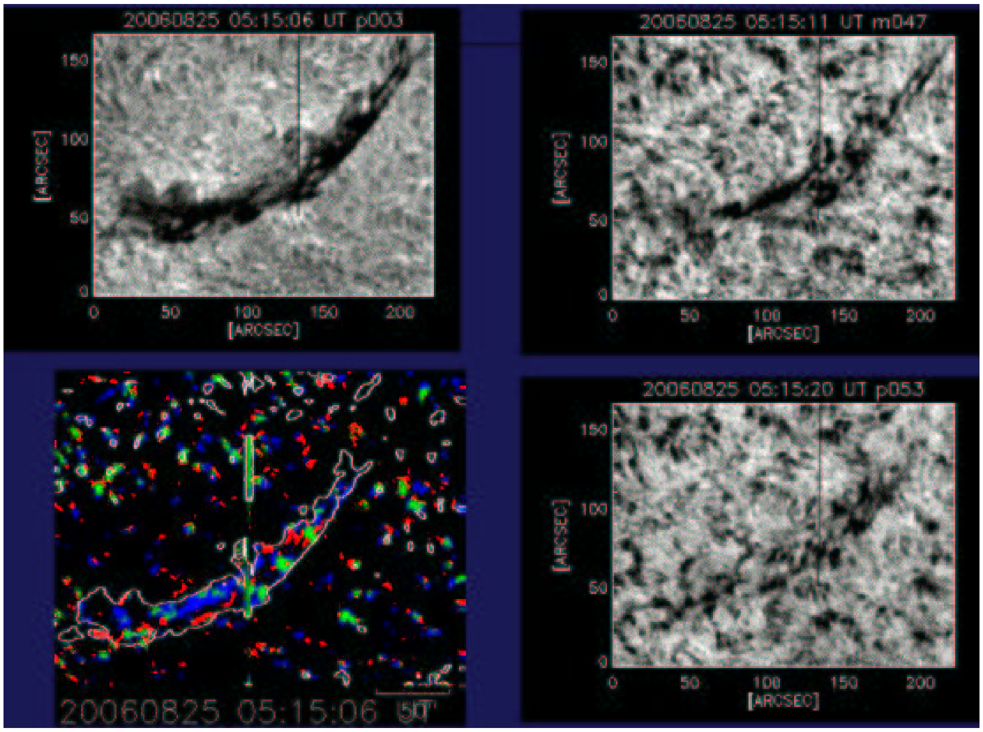

Fig. 5. Filament observed at Hida Observatory Domeless Solar telescope (DST) *top left panel*: in Hα line center, *right top panel*: in the blue wing, *right bottom panel*: in the red wing on August 25, 2006 before its disappearance (Courtesy of Kitai).

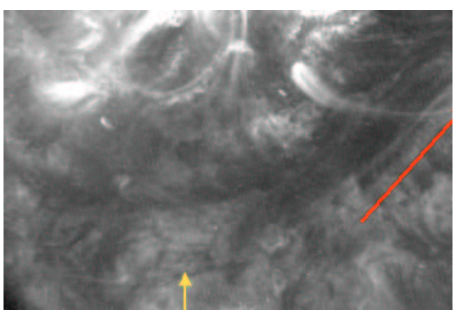

Fig. 6. Filament observed with TRACE 171 Å on August 26, 2006. Notice the fine structures of the filament visible in absorption and indicated by the white arrow. They are about 100 000km high above the dark filament channel

motion was related to the weaker anchorage of the filament (Schmieder et al. 2007).

7. Conclusion and new perspectives

The campaigns organized with THEMIS in the frames of JOP178 (filament environnement) and JOP157 (emerging flux) were using in alternance the two THEMIS modes: MSDP and MTR. MSDP allows us to have faster observations of a large area in the two Hα and Na D1 lines in 30 min. In the future, MSDP with the new cameras will be even faster. Hα and Na D1 field-of-view of 1 arcsec^2 can be obtained in 1 minute, the 4 Stokes parameters using Ca I line 6103 Å in 2 minutes; the MTR will benefit of new cameras and the acquisition rate will increase by a factor 2. THEMIS should be inserted in an European context (EAST), in an International context.

The BASS2000 database is a plus for THEMIS. A better visibility should be achieved in order that BASS2000 should be used as a database and not an archive center. The first magnetic field vector maps are in the data base since yesterday (November 10, 2006) using SQUV (Sainz Dalda code), UNNOFIT code (provided by Bommier). 70 % of the MSDP data in BASS2000 are presently reduced with the MSDP code developed by Mein. The Meudon group shows its high interest in BASS2000.

References

Aulanier G., Démoulin P. 1998, A&A 329, 1125

Berlicki A., Mein P., Schmieder B. 2006, A&A 445, 1127

Bommier V., Degli'Innocenti E., Leroy J.L., Sahal-Bréchot S. 1994, Solar Phys. 154, 231

Démoulin P., Bagala L.G., Mandrini C.H., Hénoux J.C., Rovira M.,G., 1997, A&A 325, 305

Del Zanna G., Schmieder B. Berlicki A., Mason H.E. 2006, Solar Phys., 234, 95-113

Del Zanna G., Schmieder B., Mason H., Berlicki A., Bradshaw S. 2006, Solar Phys., 239

Dudik J., Aulanier G., Schmieder B., Bommier V., Roudier T. 2007, A&A in preparation

Leroy J.C. 1978, A&A 64, 247

Li Hui, Schmieder B., Aulanier G., Berlicki A. 2006, Solar Phys., 237, 85

Lin Y., Wiik J.E., Engvold O., Voort L.R., Frank Z.A. 2005, Solar Phys. 227, 283

López-Ariste A., Aulanier G., Schmieder B., Sainz Dalda A. 2006, A&A 456, 725

Pariat E., Berlicki A., Schmieder B., Deng Y.Y., Mein N., López-Ariste A, Wang S. 2007, A&A submitted

Rondi S., Roudier T., Molodij G., Keil S., Bommier V., Sutterlin, Meunier N. Schmieder B. 2007, A&A submitted

Schmieder B., Aulanier G., Mein P, López Ariste, A. 2006, Solar Phys., 238

Schmieder B., Mandrini C., Démoulin P., Mein P. 2006, Adv. in Space Research, Vol. 37, Issue 7, 1313