Evolution of the Magnetic Field and Chromospheric Fine Structure in a Filament Channel

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Abstract. During the September 1996 Meudon-coordinated observing campaign, a filament was observed in the dispersed bipolar remnant of NOAA 7986 close to the center of the disc. Using a series of SOHO/MDI full-disc magnetograms we analyse changes in the magnetic field and the related evolution of the chromospheric fine structures of the filament, especially of its feet, as observed with the MSDP mounted on the German VTT at Tenerife. We compare the observations to recent model calculations of the filament structure by Aulanier & Démoulin (1998).

1. Introduction

Filaments are composed of cold plasma sustained by magnetic field in the hot corona. Since it is the magnetic field which provides the support for the material against gravity, one cannot understand filaments without understanding their magnetic structure. Observations show that filaments are composed of a “body” which connects to the photosphere by “feet” (e.g. Tandberg-Hanssen, 1995). The magnetic field in the prominences is mainly horizontal (Leroy et al. 1983, 1984). Two-dimensional models of prominences can not account for the existence of feet. Recently, Aulanier & Démoulin (1998) constructed a model of the magnetic field in filaments and filament channels which, for the first time, is able to model real observed features and thus can explain many observational aspects of filaments, e.g. the location and physical nature of lateral feet. We present the results of our preliminary study of the location and evolution of the filament feet which shows that the model gives a highly satisfactory match with observations; for more details see Aulanier et al. (1998a).

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Figure 1. Full-disc SOHO/MDI magnetogram and Meudon Hα spectroheliogram show the dispersed bipolar remnant of AR NOAA 7986 with a long filament along the inversion line. The arrows indicate the part of the filament and underlying magnetic field we focus on. Black (resp. white) indicate negative (resp. positive) magnetic fields.

2. Observations

On September 25, 1996, in the framework of SOHO SUMER/CDS JOP 017 (Dynamics of Solar Active Structures, DYNAC) Hα and Ca II (8542 Å) observations of a filament were obtained on Tenerife with the MSDP instrument (Mein et al, 1998) mounted on the German VTT and with the SOHO/MDI.

The Multichannel Double Pass (MSDP) instrument (Mein, 1991), observed the Hα and the Ca II (8542 Å) lines simultaneously, recording 9 and 10 channels in the line profiles, respectively. The size of the field is typically 20″ × 180″. A bigger area of the surface can be scanned by shifting the field of view after each exposure. The usual observing sequence consists of 6″ × 150″ steps and during this campaign it covered up to 5.5′ × 12.5′.

One of the twelve SOHO instrument packages is the Michelson Doppler Imager (MDI), which is being used by the Solar Oscillations Investigation (SOI) to measure the photospheric manifestations of solar oscillations (Scherrer et al, 1995). The MDI instrument obtains full-disc and partial frame line-of-sight magnetic field measurements. Full-disc magnetograms, used in this paper, are taken at about every 90 minutes, with a pixel size of 2″.

3. Results and Discussion

On September 25, 1996, the filament was observed in the dispersed bipolar remnant of NOAA 7986 close to the center of the disc (Figure 1) and went through repeated disparition brusques, connected to CME events (see e.g. Schmieder et al. 1997, van Driel-Gesztelyi et al. 1998). We co-aligned the MSDP Hα and
Figure 2. MSDP Hα and Ca II (8542 Å) observations (top and middle row) co-aligned with SOHO/MDI magnetic maps (bottom row) show that the shape and orientation of the filament feet depend on the presence of parasitic polarities in the filament channel. Note that the changes in the shape and inclination of the middle-western foot (in the centre of the images) are due to the changes in the strength and position of underlying parasitic (here: negative) polarities.

Ca II images with the MDI full-disc magnetograms (Figures 2 & 3). In spite of the fact that MDI had a data gap during the best MSDP observing hours, we find that the evolution of the filament feet follow the evolution of the parasitic polarities in the filament channel. The observations indicate (cf. Figures 2 & 3) that the shape and orientation of the filament feet depend on the presence of parasitic polarities in the filament channel. Furthermore, the changes in the shape and inclination of the middle-western foot are due to the changes in the strength and position of underlying parasitic (here: negative) polarities. At first, the foot appears in between the positive and the south negative polarity. Later, as the south negative polarity is weakened by cancellation and the north negative polarity is moving out of the filament, the foot is gradually shifting northward and appears more and more between the positive and the north negative polarity.

These observations are in good agreement with the recent filament model by Aulanier & Démoulin (1998). It has been shown by the model that the best configuration for a filament is a slightly twisted flux-tube, which is perturbed by parasitic polarities in the main bipolar filament channel. Some lateral dips
Figure 3. De-rotated and co-aligned SOHO/MDI images show the evolution of the parasitic polarities under the filament foot during 17.5 hours. The boxes (size=50") are fixed at a constant solar position. As the polarities move and cancel the morphology of the filament foot is changing (cf. Figure 2).

of the field lines appear at low heights, on each side of the main inversion line. They stand right above secondary inversion lines at the edge of these parasitic polarities. Their shape and their distribution lead to lateral and underlying feet structures, while other small isolated groups of dips could be interpreted as dark fibrils or plages. The dips are assumed to be filled with dense plasma up to a given height (1,000 km), which makes them visible. Naturally, changes in the position and intensity of the magnetic polarities in the filament channel shift the position of field line dips which form the filament feet, just as our observations show.

The existence of magnetic dips in the context of filament support has been questioned by many observers, though for a long time theorists have been proposing magnetic dips as the main physical process which provides a long time
stability to filaments. The good correspondence between the model and our observations provides strong support for that theory (cf. Aulanier et al. 1998b).

References

Aulanier G., Démoulin P., van Driel-Gesztelyi L., Mein P., & De Forest C. 1998b, this volume, 326