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SPECIAL ISSUE
Contributed and Poster Papers
IAU Coll. No. 117 "Dynamics of Quiescent Prominences"
Hvar, SR Croatia, Yugoslavia, 25-29 September 1989
Edited by V. Ruždjak and E. Tandberg-Hanssen

(for Table of Contents see p. iii)

PREFACE

In this issue we publish the contributed and poster papers presented at the IAU Colloquium No. 117 "Dynamics of Quiescent Prominences", Hvar, September 25-29, 1989.

The site of the meeting was the pleasant, medieval town of Hvar on the island of Hvar. The Colloquium was endorsed by IAU Comissions 10 and 12, and financial support was received from IAU and the University of Zagreb. 89 participants from 23 countries participated in the meeting where 11 invited talks, 49 contributed papers, and 16 posters were presented. Major invited reviews were presented by S.F.Martin, I.S.Kim, B.Rompolt, F.Chuideri-Drago, B.Schmieder, J.-C.Vial, A.I. Poland, E.Jensen, E.R.Priest, T.Hirayama and E.Landi Degl'Innocenti.

Considerable progress has been made recently in our understanding of the physical properties of prominences, and particulary in their dynamic nature, and the time was ripe for an exhaustive discussion of this topic. As a result a model for quiescent prominences was developed, and the details formulated during a panel discussion led by O.Engvold.

The invited reviews, extended abstracts of the contributed and poster papers as well as the "Hvar Reference Atmosphere for Quiescent Prominences" are published in Springer Verlag Series "Lecture Notes in Physics".

The Scientific Organising Committee included O.Engvold, J.Kleczek, J.L.Leroy, M.Machado, H.Morozhenko, E.Priest, E.Tandberg-Hanssen (Chairman) and V.Ruždjak.

The Local Organising Committe was composed of K.Brajša, R.Brajša, M.Malarić, D.Plačko-Vršnak, V.Ruždjak (Chairman) and B.Vršnak.

ZAGREB AND HUNTSVILLE
DECEMBER 1989

V. RUŽDJAK
E. TANDBERG-HANSSEN

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TABLE OF CONTENTS

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FORMATION OF A FILAMENT AROUND A MAGNETIC REGION

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ABSTRACT

The evolution of active region AR4682 observed in 1985 during six rotations was dominated by three different phenomena:

. the large-scale pattern activity: relationship between two active regions, formation of a quiescent filament during the decay phase of the active region

. the presence of two pivot points along the filament surrounding the sunspot with the long-term one associated with the long-duration filament and with the short-term one the active filament and its temporaly disappearance

. the magnetic shear during one rotation

The magnetic field lines have been extrapolated from photospheric data using Alissandrakis'code (1981). The magnetic configuration with the existence of a dip favors the formation of a filament. We note that the shearing of the sunspot region and the filament are both well described by force-free magnetic fields with the same constant α. This suggests that they are both a consequence of the same shear process.

1 Long-Term Evolution of Active Region 4682

1.1 Observations

Active region NOAA-AR 4682 located at S15-E10 has been observed with different wavelength instruments (see Table I):

. in Hα with the Meudon spectoheliograph and with the Multichannel Subtractive Double Pass (MSDP) spectrograph, operating at the Meudon solar tower

. in photospheric lines with the Meudon and Marshall SFC magnetographs and with the Meudon spectroheliograph (Ca II K_3 line)

. in U V lines with the High Resolution Telescope and Spectrograph (HRTS) on the Spacelab 2 pallet aboard the space shuttle (Brueckner *et al.* , 1986; Schmieder *et al.* , 1989, Dere *et al.* , 1990),

. in microwaves with the V L A (Kundu, Schmahl, and Fu, 1989).

1.2 Large-Scale Pattern

On the VLA observations the presence of a giant coronal loop visible connecting two large active regions north and south (AR 4682) is detected (Kundu , Schmahl, and Fu, 1989).

The evolution of AR 4682 is followed, using spectroheliograms during four successive rotations (Figure 1). The birth, development, and final disappearence of a sunspot is visible, as well as the evolution of the filament bounding the active region. The Hα threads around the sunspot are initially radial, but subsequently form a spiral structure at the same time as a plage filament appeared . During the rotation (1764-1765), the magnetic shear increases (Section 2) while portions of the filament progressively disappear (August 2, 1985). At the end of the observational period the Hα topology changes dramatically, implying a complete restructuration of the magnetic field. The sunspot disappears and the plage filament is restructured into an extended quiescent filament (September 27, 1985).

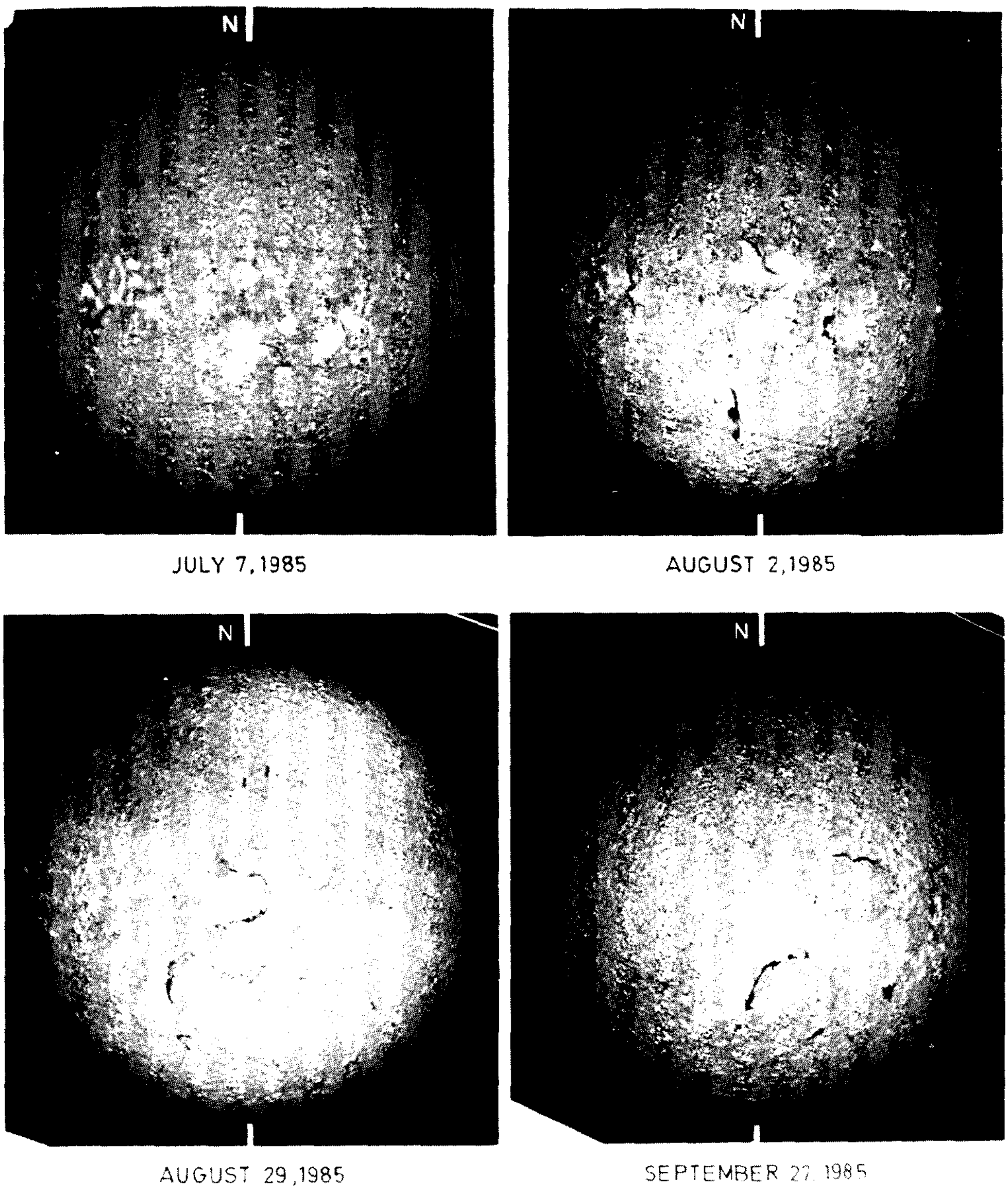

Fig. 1. Hα spectroheliograms obtained at Meudon showing AR 4682 during four rotations.

TABLE I
Characteristics of A R 4682 observed in 1985
with the Meudon spectroheliograph

Rotation	Date	Longitude	Meudon Magnetograms	Marshall Magnetograms	HRTS Spacelab 2 Mission
1763	June 9	0			
1764	July 7	0			
	July 10	45 W			
	July 29	65 E		20:00	
	July 30	50 E		14:52	
	July 31	40 E		14:37	
	August 1	25 E	09:42	14:18	13:38 (43)
	August 2	13 E	13:04	21:22	09:17 (56)
1765	August 3	0	15:15		02:14 (67)
	August 4	13 W		15:41	01:00 (82)
	August 5				09:00 (103)
	August 6				
	August 28	30 E			
	August 29	10 E			
1766	September 27	0			
	September 29	30 W			

1.3 Pivot Points

Looking at the synoptic maps for preceding rotations and following ones we evidence two pivot points, one located above the spot at 12^0, the other one at 28^0 (Figure 2). The first one is visible during six rotations and is associated with the long-term life quiescent filament, the other one disappears after the rotation 1764-1765, a rotation with great shear and partial filament disappearance. It is in good agreement with the Mouradian and Soru-Escaut (1989) results which show that disappearances of filaments are temporary if one pivot point exists along the filament. The pivot points have a rigid rotation and they are in a region favoring new emerging flux and activity.

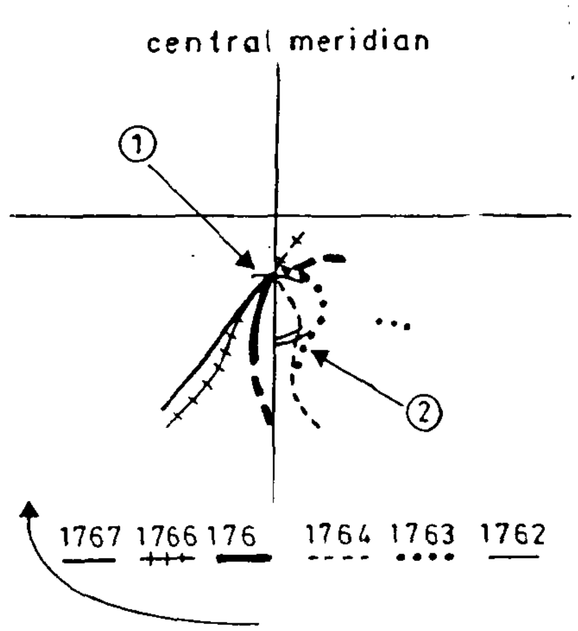

Fig. 2. Pivot points found from synoptic map study during six rotations. Pivot 1 (respectively pivot 2) is a long-term (short) pivot (courtesy of M.J.Martres).

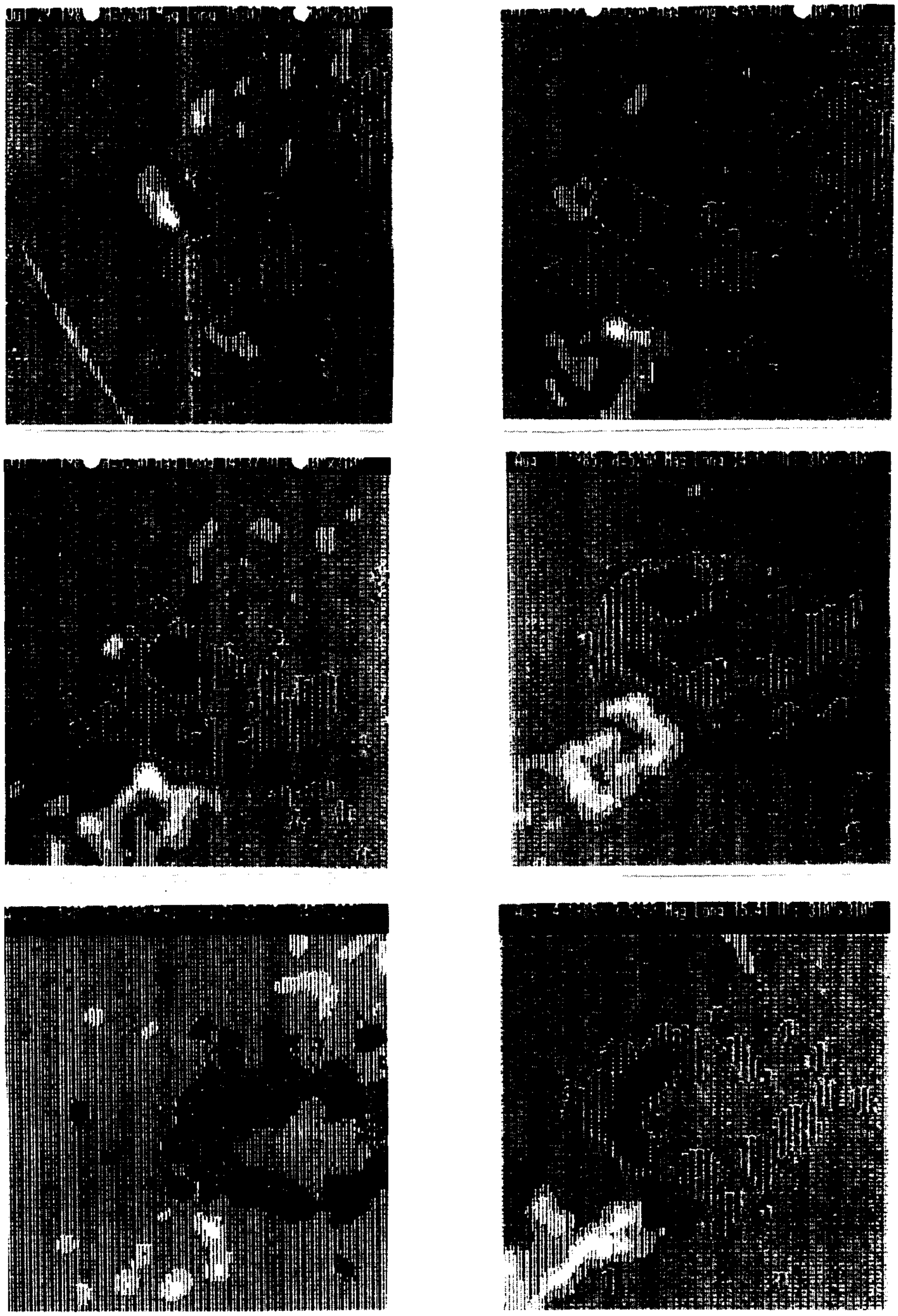

Fig. 3. Marshall magnetograms. Dark represents negative polarity, white positive polarity (courtesy of M. Hagyard).

1.4 Role of the Magnetic Shear

The set of magnetic field maps presented in Figure 3 shows the evolution of the magnetic field. There is an accretion of the southern negative polarity surrounding the spot of the same polarity within clockwise motion (see Section 2) while the positive polarity is developing. This is a good example of two regions of opposite polarity moving with anti-parallel motions. This configuration may be responsible for the formation of the filament squeezed between the two different polarity zones. This observation is in agreement with the sketch presented by Rompolt and Bogdan (1986).
The active center is complex. A new bipolar group appears between July 7 and July 9, 1985; the leading spot is growing up and includes the leading spot of the old sunspot group (Figure 4). This large sunspot will decrease while the shear increases in a clockwise direction (see Section 2). Horizontal photospheric clockwise vortex motions are connected to the decay of southern leading spot. It conforms to the vorticity polarity rule in the growth of sunspots (Martres *et al.* , 1982, Martres, Soru-Escaut, and Rayrole, 1973).

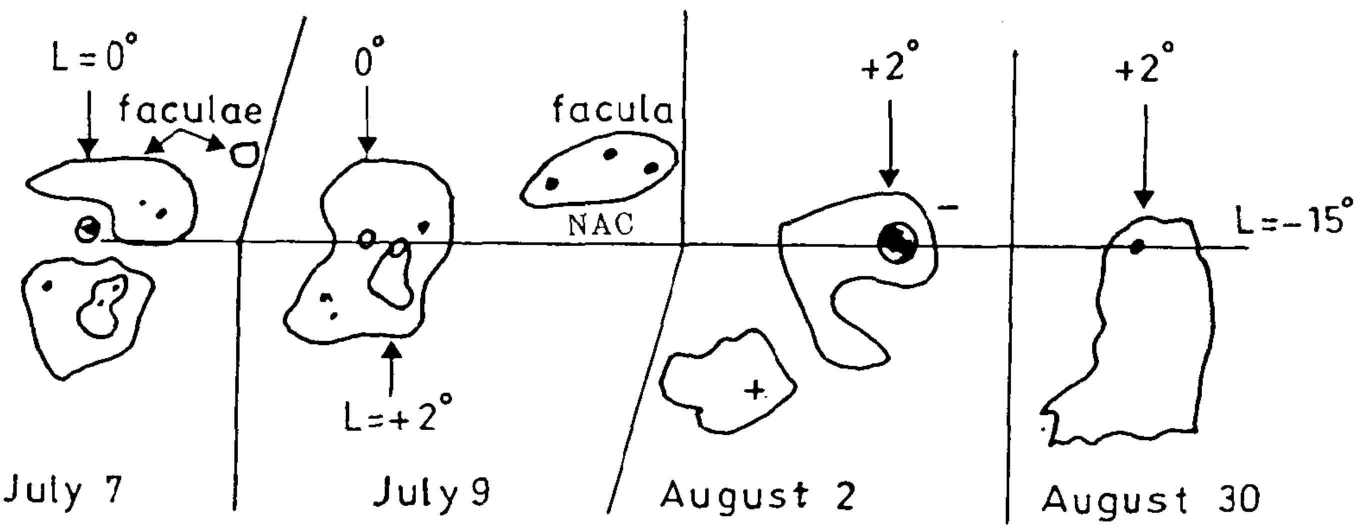

Fig. 4. Evolution of AR 4682 sunspots using Ca II K_3 spectroheliograms. Note the new active center (NAC) on July 9 (courtesy of M.J.Martres).

2 Force-Free Field Computation

More quantitatively we have derive magnetic vectors using observations of longitudinal photospheric magnetic field component and compare the direction of this vector with the alignment of the fibrils in Hα and of the downward motion structure in the transition region (Schmieder *et al.* , 1989, 1990).
Previous studies have shown a reasonnable topological agreement between a class of constant α force-free magnetic fields and Hα structures (Nakagawa and Raadu 1972, 1973).

In order to compute the vector of the magnetic field, we have made the following assumptions:

. the field is static (the evolution time is larger than the Alfvén and sound transit times)

. the plasma velocity is neglected because the magnetic field is large

. ideal MHD is appropriate since the magnetic Reynolds' number is large for typical lengths of magnetic structures

. the gravitational and pressure forces are negligible compared with the magnetic force ($\beta \ll 1$). Thus the magnetic field satisfies the equation:

$$\vec{j} \times \vec{B} = \vec{0}.$$

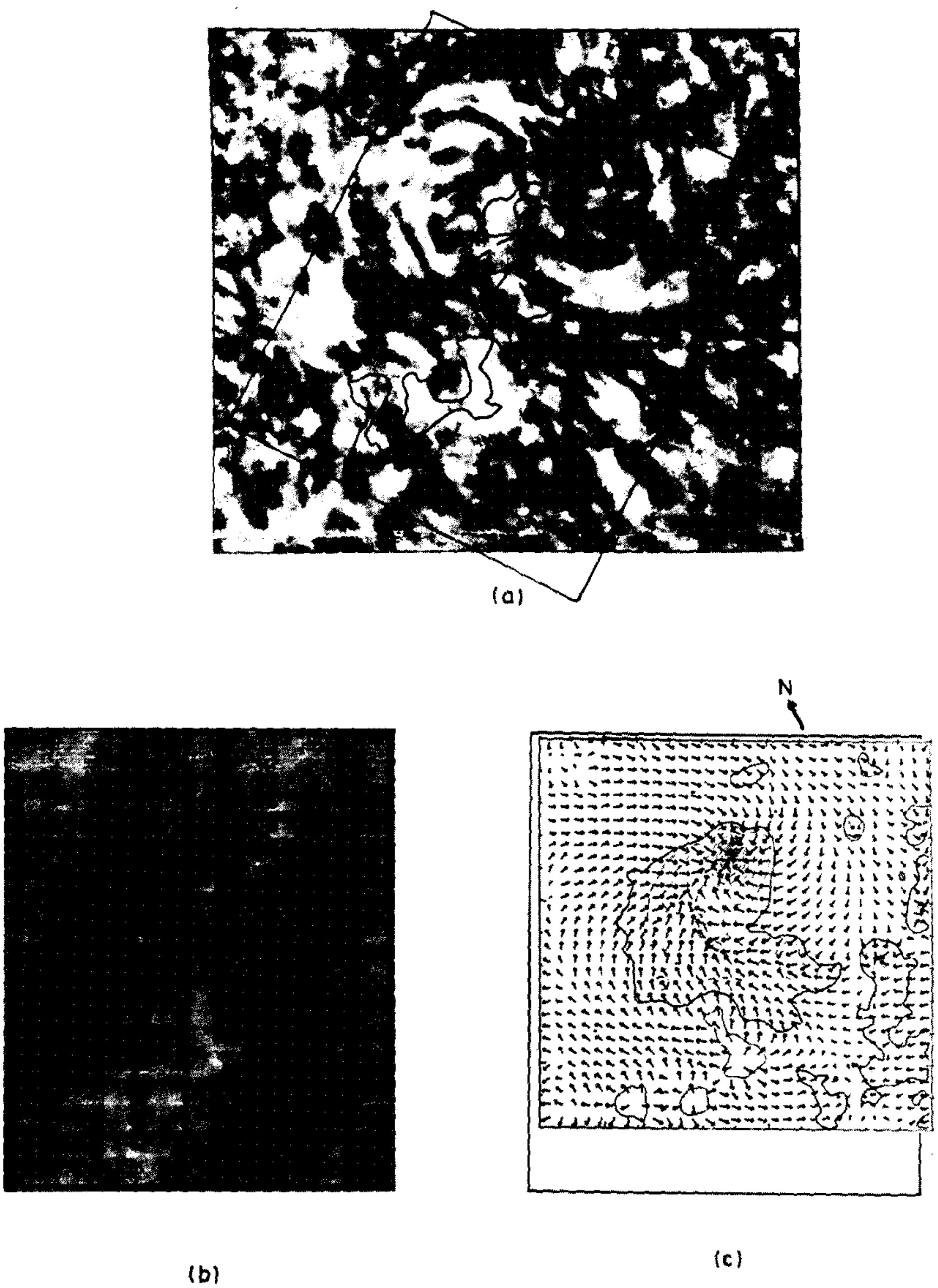

Fig. 5.(a) MSDP Hα intensity map of AR 4682 on August 2 1985. The box represents the field of view of the (b) map. The contours correspond to maxima of the magnetic field. (b) Magnetic field observed at Meudon at 9:42 UT on August 2, 1985. Dark regions correspond to negative polarity, white regions to positive polarity. (c) Magnetic field computation with force-free field assumption for $\alpha = 0.7$ in units (190 Mm)$^{-1}$) at the altitude $z = 2000$ km (the arrows indicate the direction of the horizontal component, continuous lines maxima of the vertical component). The sunspot and the filament are located in the center of the area. The filament lies along the inversion line of the computed field. If we increase the altitude z, the contours are smoothed but the arrow direction is conserved.

We limit the computation to the case of a linear force-free field with α = constant over all the computed grid because our data are restricted to the longitudinal field component only. A posteriori, this assumption seems to be acceptable because the Hα structures fit well with linear force-free field lines.

The method that we use solves the problem in terms of Fourier series (Alissandrakis, 1981). Since we impose a periodic behavior, difficulties are located at the boundaries but should affect only 10% of the area.

We obtain the following results with Meudon observations obtained on August 2, 1985. For α positive, the field is sheared in a clockwise direction like the observed spiral fibrils and a single value of α can be found that provides a good match to the observed fibril pattern (Figure 5). This indicates a causal relationship. The field strength is decreasing with the altitude outside the filament and constant or weakly increasing in the filament (Figure 6). Then a dip is present in the field line configuration where initially the matter could be condensed and a filament forms. This concerns the portion of the filament squeezed between the two opposite magnetic field regions. This portion is particularly dynamical with high outflows observed in C IV line of the order of 50 km s^{-1} (Schmieder *et al.* 1989, 1990). The presence of shear of $\vec{B}$ favors the existence of filament but also, for large shear, decreases the stability of the field (see Priest, Anzer, and Hood, 1990). The destabilization of the filament may be explained by the local changes of filament equilibrium conditions due to the slow evolution of the magnetic field in a bipolar region or increase of current, for example (Démoulin and Priest 1988).

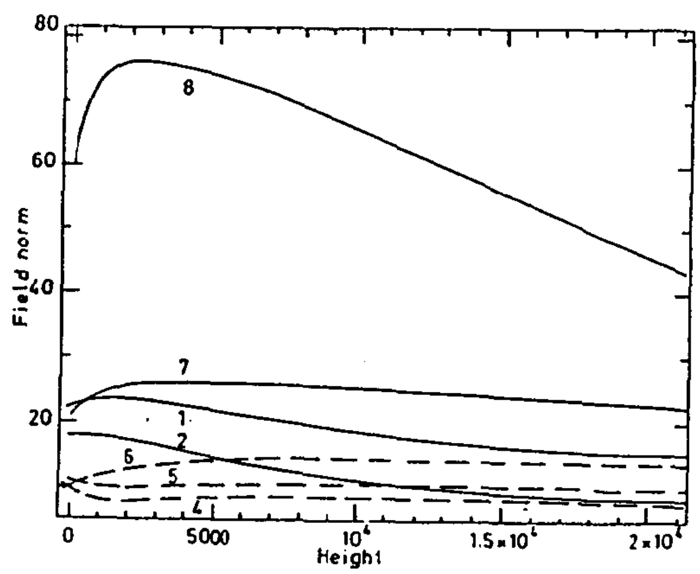

Fig. 6. Magnetic field strength versus height for different points in (dashed lines) and out (continuous lines) the filament.

3 Conclusion

It is shown that the formation of a large quiescent filament is due to large-scale, anti-parallel converging mass motions. The shearing of the sunspot region and the filament are well described by a force-free field with an α value, then a large-scale process is invoked. Without introducing any current from the filament equilibrium in the coronal magnetic force-free field, it is shown that the field lines present a dip at their top, and then they can support dense material. It is in good agreement with the theory of Priest Anzer, and Hood (1990) and Amari *et al.* (1990) exhibiting the importance of shears in filament formation.