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Morphology of H-Alpha Filaments and Filament Channel Systems

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Abstract. Ring-like filaments have been detected on the spectroheliograms in the H-alpha line. Inside these filaments the magnetic field flux has a predominant polarity. Some of the dark filaments are connected by filament channels which can be seen at the limb either as (a) weak prominences or (b) dense low chromospheric features or (c) multi-channel system of matter flow between two prominences or (d) common quiescent prominences. The filament and the filament channel together form a continuous closed contour and outline the region of the *f* polarity particularly at the beginning of the solar cycle. The change in sign of the polar field of the Sun is associated with the drift of the filament band to high latitudes.

Key words: Sun—magnetic fields—filaments—filament channel

1. Introduction

Quiescent filaments and prominences, most clearly seen in the H-alpha line, have a distribution far from random on the solar surface. Their location is intimately associated with the distribution of solar magnetic fields which is characterised by an inhomogeneous structure and varying coverage over the disc (Babcock and Babcock 1955; McIntosh 1972a).

The smallest scale of magnetic fields at the photospheric level is located mostly in structures of the order of granulation or less (Stenflo 1976; Krat 1977). On the cells comparable with an active region, a noticeable predominance of the field of one polarity is observed. Filaments are formed along the dividing line of opposite polarities of this large-scale magnetic field (McIntosh 1975). On the basis of an analysis of the filament-band motion, Makarov and Fatianov (1980) have studied the process of the sign-change of the polar magnetic field of the Sun in the 20th solar cycle, and have also given a forecast for the 21st cycle. We report here the results of a study on the morphology of the large-scale filament structures and their relations with the distribution of the large-scale magnetic field on the solar surface.

2. Data

The Kodaikanal Observatory plate collection has an extensive series of spectroheliograms in the H-alpha and K line of Ca II since 1904. Our present study is based on these spectroheliograms for the period 1905–1979 and the H-alpha filtergrams of the Kislovodsk station during 1969–1980.

3. Structures formed by single filament

A very interesting feature which we have detected on the spectroheliograms of the Kodaikanal Observatory and on the Kislovodsk filtergrams is a continuous filament which forms a closed circular contour. A few examples of such structures are presented in Fig. 1. We use the term 'ring filament' to designate these structures. The filament intensity on the contour is not uniform. Such structures can be detected particularly during the maximum phase of the solar cycle. Their mean size seldom exceeds 10°. Their lifetimes occasionally span over several days. For instance, a ring filament could be traced from 1979 March 4 to 8 in the H-alpha spectroheliograms, but as a rule part of the ring filament becomes invisible in a day. Identification of the location of several such ring filaments with reference to magnetic fields using the Mount Wilson and Kitt Peak magnetograms show that the circular filament outlines an island of opposite polarity magnetic field with respect to its surroundings. In Fig. 3, we illustrate one example of the ring filament–magnetogram pair.

A single dark filament in the centre of the H-alpha line gives an impression of a system of elements which build up the common structure, each element forming a coil of the helix. On the disc, the filament is formed by the piling of several arches (Fig. 2), which show up as a spiral and sometimes as a helical structure at a certain projection to the limb. Such a structure is suggestive of a prominence with rotational motion (Öhman 1969). The matter of the filament is concentrated in the helical coil and has no apparent direct connection with the photospheric layers. The matter in the denser elements flows down, forming arch-like feet on the disk or the footpoints of the prominence.

4. The filament channel

In the core of the H-alpha line, single filaments are seen connected with one another by a regular structure of dark chromospheric elements of several tens of degrees in extent or at times by a conglomeration of absorption grains of 1° to 3° in length (McIntosh 1972a, b; Makarov and Stoyanova 1979). Such chromospheric structures with floccular corridor termed in the literature as filament channels are known to be

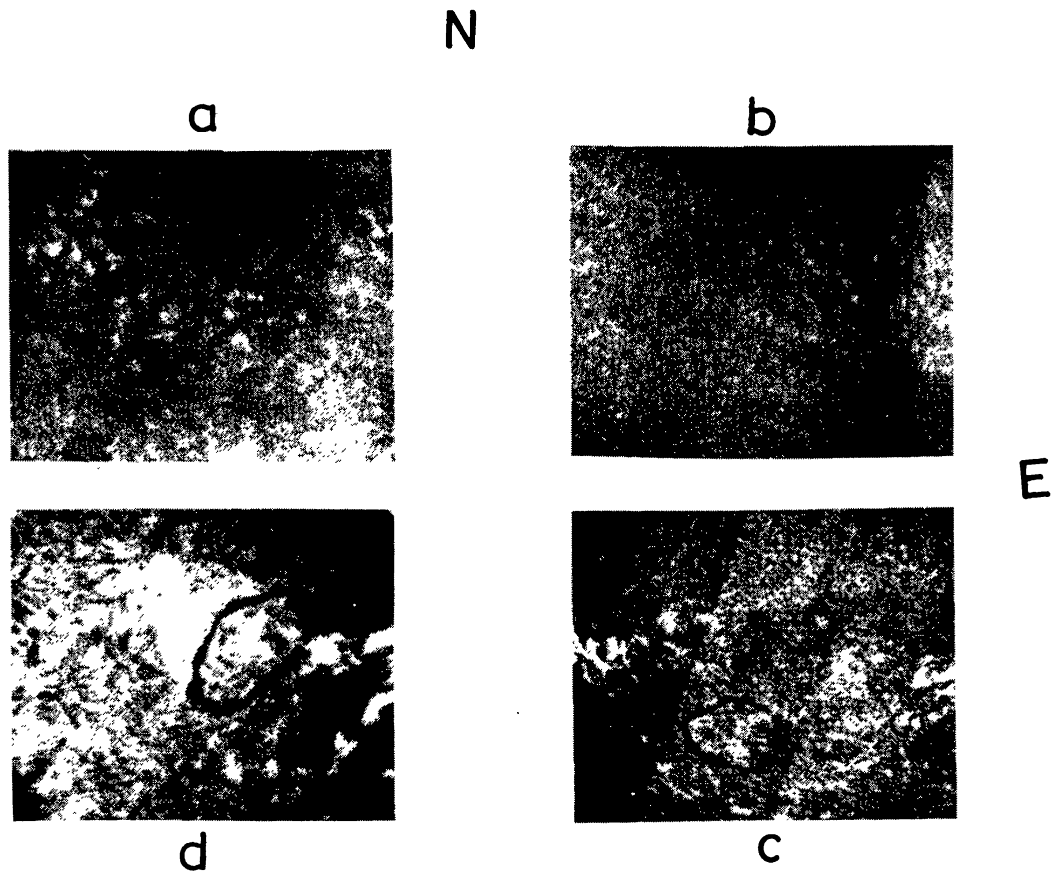

Figure 1. Portions of H-alpha pictures showing 'Ring filaments'. (a) 1918 August 13, (b) 1921 November 14, (c) 1978 December 17, (d) 1980 June 7, (a), (b) and (c) are Kodaikanal spectroheliograms; scale : 1 cm = 10^5 km on the Sun. (d) is Kislovodsk station filtergram; scale : 2 cm = 10^5 km on the Sun.

Figure 2. H-alpha spectroheliogram of 1938 February 13 showing the arch-like structures within the filament (Kodaikanal Observatory).

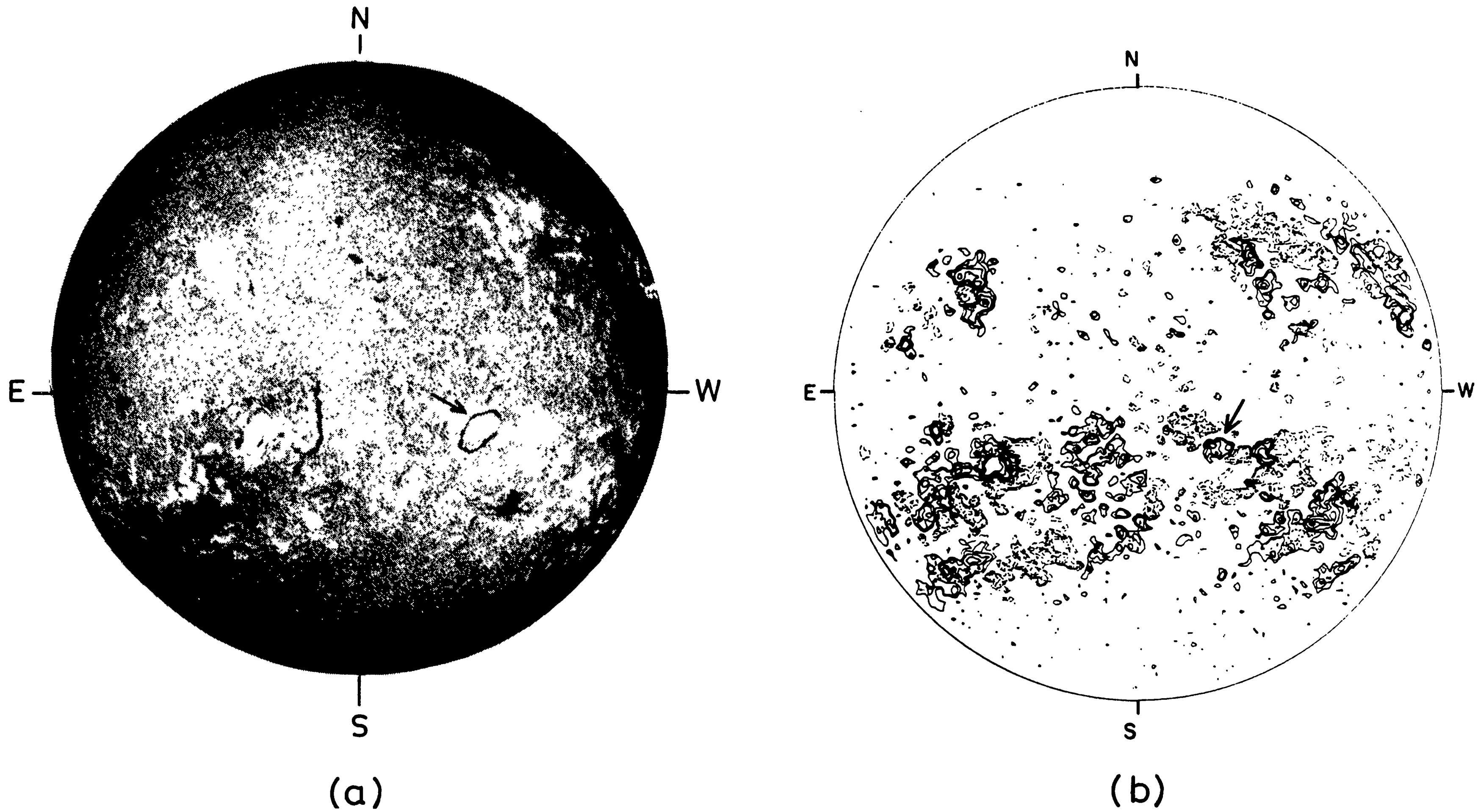

Figure 3. Filtergram-magnetogram pair, (a) Kislovodsk H-alpha filtergram at 0495 UT of 1980 June 7. The arrow indicates the ring filament. (b) Mt. Wilson magnetogram at 1652-1775 UT of 1980 June 6 (from Solar Geophysical Data, Prompt Reports). The arrow shows the location corresponding to the filament on the magnetogram. Notice that within the filament ring the magnetic field is of one polarity.

located on the polarity-inversion line of the large-scale magnetic field. On the limb the filament channel can show up either as weak prominences, or dense chromospheric features extending to small heights, or as multichannel flows connecting two prominences or as quiescent prominences. They are invisible on the solar disc as dark filaments, because the optical depths along the line of sight is much less than unity.

Occasionally, prominences can be detected which are located above filament channels. In this case, an elongation of some arches of the filament channel may take place with an associated local increase in intensity in the corona. Such prominences do not show up on the solar disk as a visible filament. However, continuous long-term observations of such prominences enable us to realize that they form a continuous contour in the chromosphere as depicted in synoptic charts (Fig. 4b). This prominence property can best be seen in polar regions at the maximum epoch of the cycle (Fig. 4a). The polar ring filament separates the old background magnetic field from the new one in the middle latitudes, which formed during the subsequent period of solar activity. Subsequently, the disappearance of the filament is observed, but the polarity-dividing line remains and shows up as a filament channel. The existence of the filament channel is confirmed by the presence of continuous prominences on the east and west limbs (Fig. 4b). The filament channel is a more stable and long-lived feature than the filament itself.

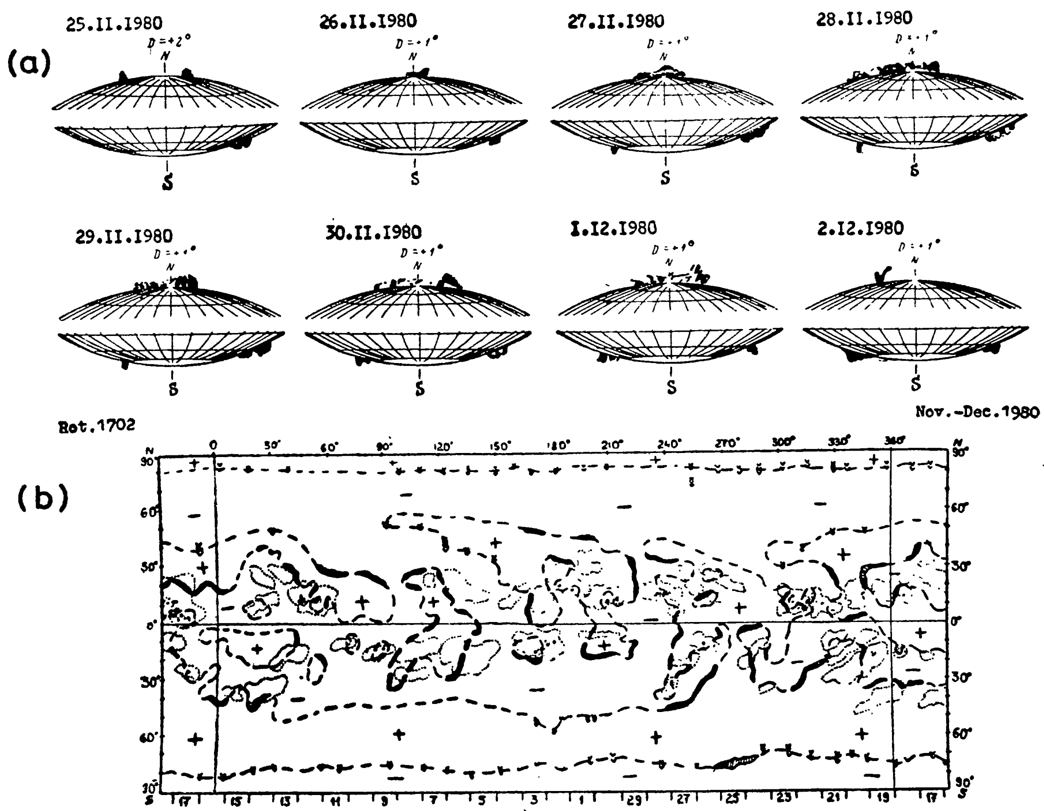

Figure 4. (a) Day-to-day solar maps from 1980 November 25 through December 2. (b) Sample synoptic chart. Prominences are observed in north and south polar regions and filaments are invisible on the east and west limbs. On the synoptic chart, prominences are marked thus **V**. They form a polar band of filament channels (Kislovodsk).

The number and area of filaments and prominences are parameters closely associated with solar cycle changes on the Sun. The evolution of filaments and filament channels portray the evolution of large-scale magnetic fields and hence can be used as tracers to study their motion on the solar surface. Such a detailed study extending over a few solar cycles is in progress and the results will be reported in a subsequent paper.

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