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ON THE FORMATION OF ACTIVE REGION PROMINENCES (Hα FILAMENTS)

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ABSTRACT: Analysis of sequential Hα images of active region prominence formation suggests that simple large-scale photospheric mass-motions may play a key role in the formation of these long, thin, Hα filaments.

INTRODUCTION

Detailed investigations by one of us (B.R.) of the temporal evolution of the fine structure of active region prominences has prompted us to explore the possible influence of hypothetical large-scale photospheric velocity fields on the formation of active region filaments.

Our observations are based upon sequences of Hα images of active regions taken by the Big Bear Solar Observatory, Holloman and Ramey US Air Force Base Observatories, and the Sacramento Peak National Solar Observatory. In addition, a number of high resolution Hα limb photographs from the Astronomical Observatory of Wroclaw University has been employed.

The striking feature of these observations is that the formation of Hα filaments appears to be consistent with the presence of a hypothetical large-scale shear flow in the vicinity of the (eventual) filament axis (see e.g., Fig. 1). In some cases, the observations would further suggest a smaller converging velocity component directed towards the filament axis or line of magnetic field polarity reversal (hereafter called the neutral line). While direct evidence for shear flows in active regions has been reported (Martres et al., 1971, 1974, 1977; Harvey and Harvey, 1976, 1980; Athay et al., 1985a,b, 1986a,b), so far as we know, simultaneous Hα and ve-

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locity field observations of active region filament formation have not been obtained, so our conjectures are so far unsubstantiated.

OBSERVATIONS

In well developed active regions, one generally observes a hierarchy of dark Hα filaments radiating outward from the main sunspots. Beyond the penumbra is a system of fine chromospheric filaments forming the superpenumbra (Loughead, 1968). These filaments usually begin within the penumbra and run outwards, in a more or less radial direction, for a distance on the order of the sunspot diameter. Another set of shorter filaments (fibrils) is found beyond the superpenumbral filaments (see Fig. 1a). It appears that active region prominences are formed from these outlying systems of filaments.

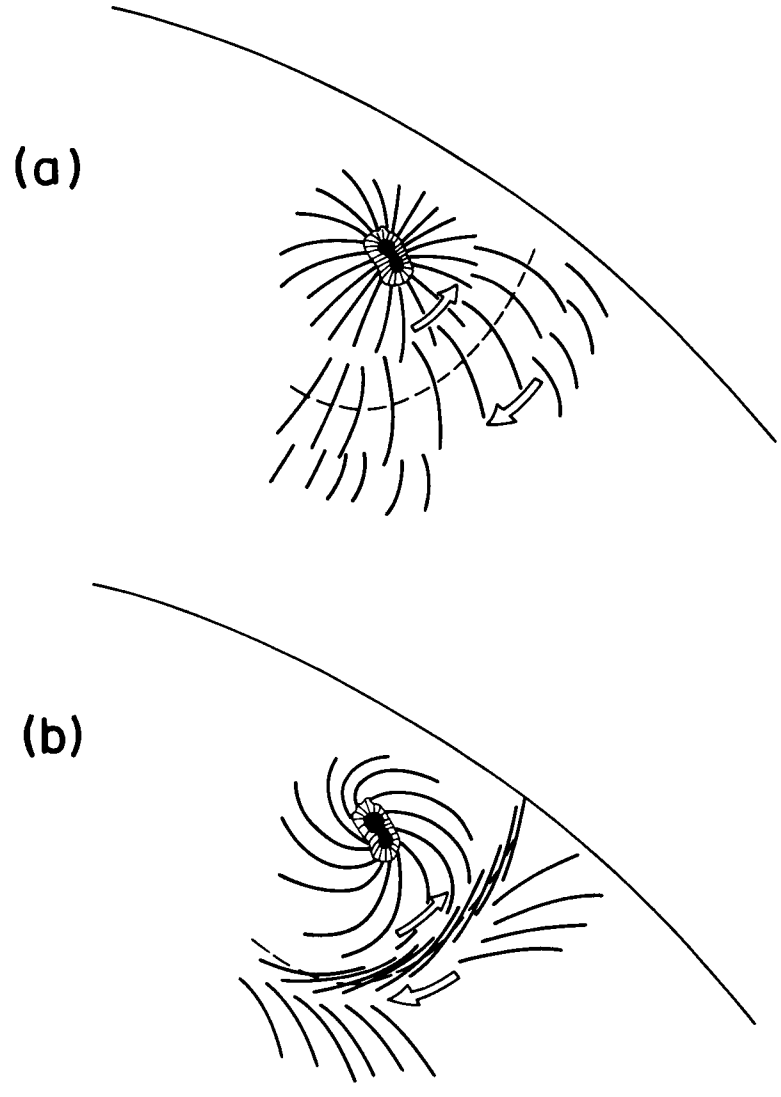

Fig. 1. Hα filament formation in anti-parallel converging mass motions.

Figures 1 and 2 illustrate two fairly typical sequences, and the concomitant hypothetical photospheric mass motions, by which active region prominences form.

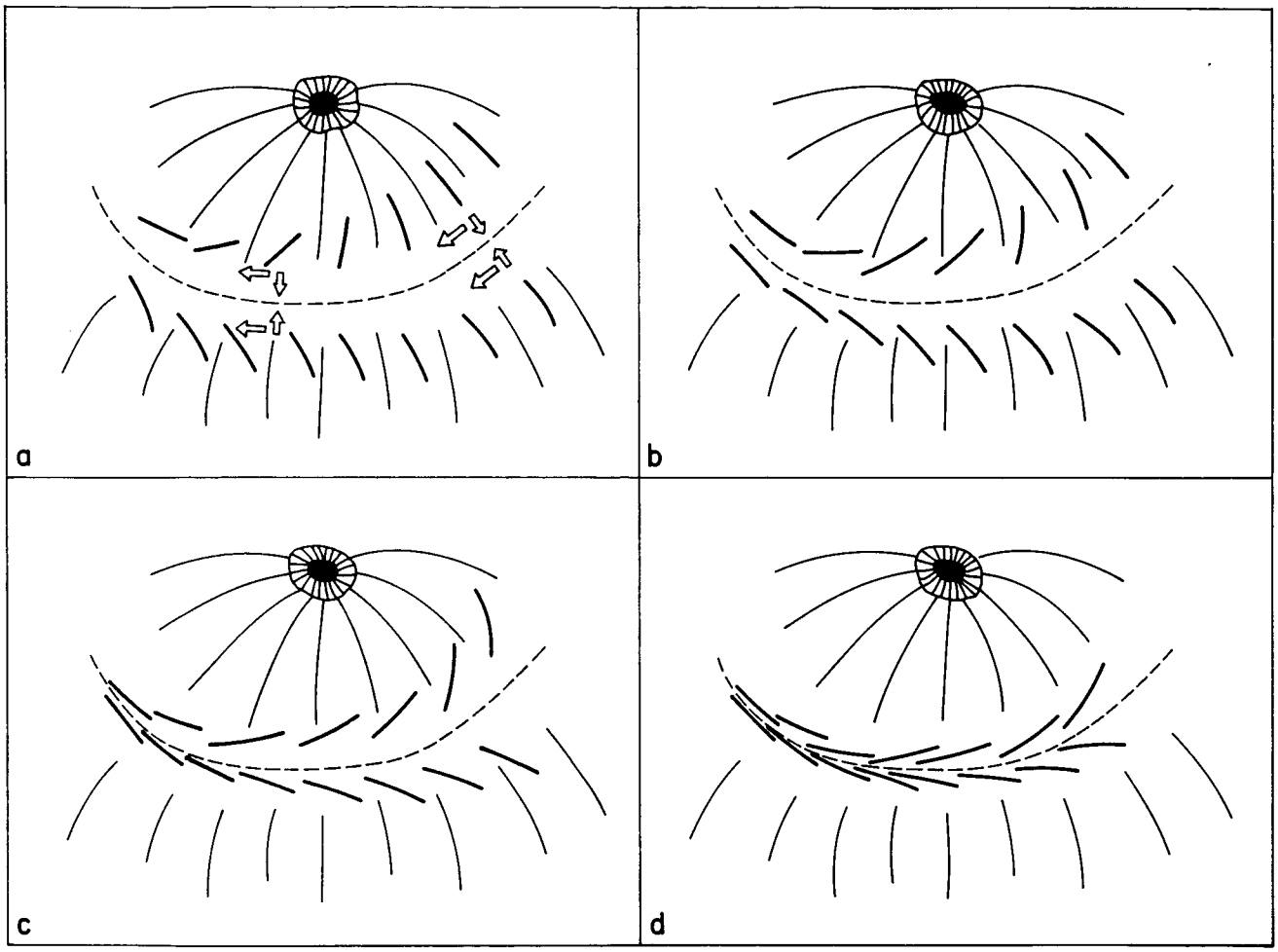

Fig. 2. Hα filament formation in parallel converging mass motions.

In Figure 1 a system of fibrils, initially oriented approximately perpendicular to the magnetic neutral (dashed) line, is sheared by mass motions (indicated by arrows) at the photospheric level forming a long Hα filament consisting of tightly packed fibrils. In Figure 2, two series of fibrils are sheared and then merged and tightly packed by a flow with a velocity component directed towards the neutral line. Note the difference in the arrangement of fibrils between Figures 1b and 2d, which results from hypothetical mass motions being anti-parallel (Fig. 3a), or parallel (Fig. 3b) on either side of the neutral line.

Our analysis of sequential Hα images so far indicates that the majority of active region prominence formation is typical of Figure 1, and by inference, the mass motions of Figure 3a. Figure 4 is an example of an Hα filament formed by the sequence of Figure 1, whereas Figure 5 is representative of the Figure 2 formation scenario.

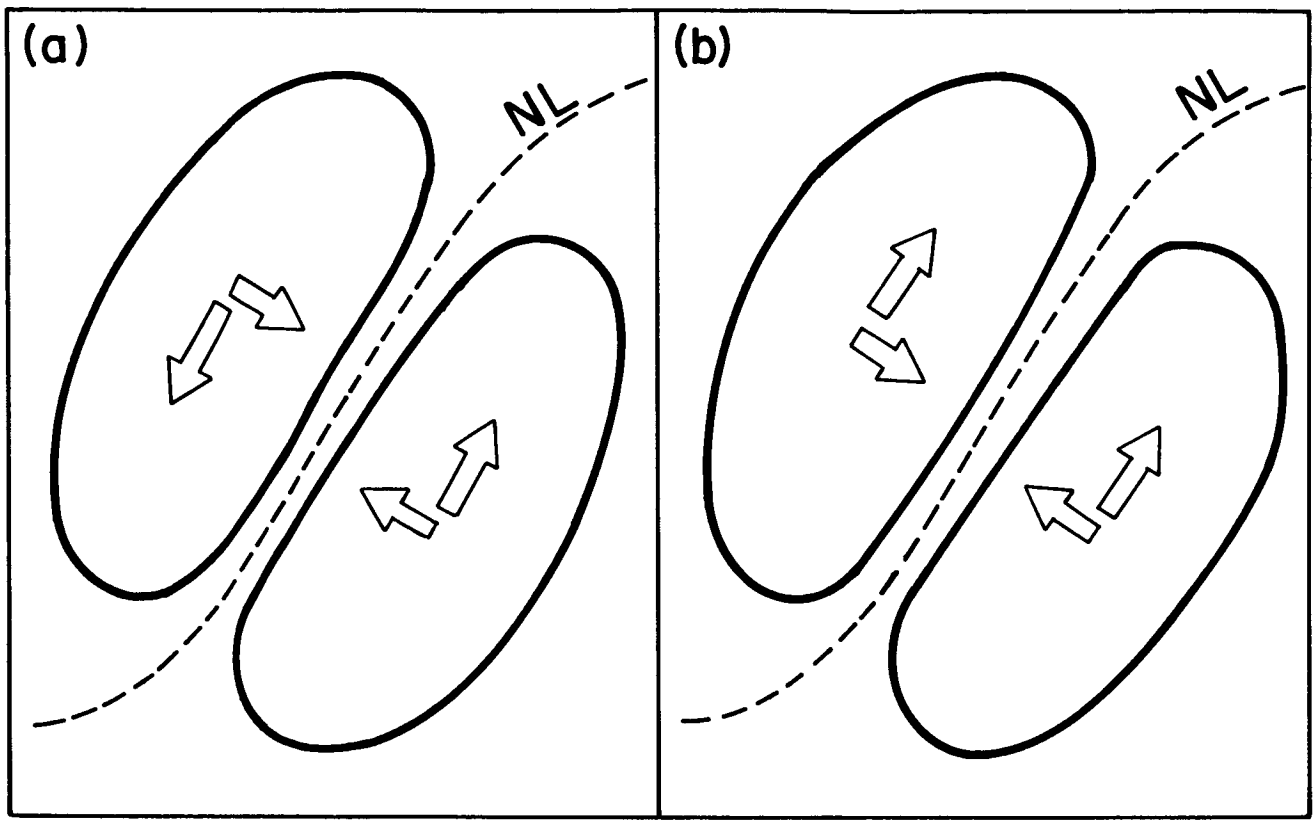

Fig. 3. Two types of converging mass motion about the magnetic neutral line (NL).

DISCUSSION

Investigation of sequential Hα images suggests that the observed evolution and subsequent formation of active region prominences from outlying systems of fibrils about sunspots may be the result of some simple photospheric mass motions.

While following evolutionary changes of individual fibrils during formation of Hα filaments we often found some fibrils to disappear for several tens of minutes to hours. After some time these fibrils reappeared again displaying changes in location and inclination with respect to the neutral line. Sometimes new fibrils, not seen earlier, abruptly became visible in the region of filament formation. This peculiar behaviour of fibrils made the observation of their evolutionary changes difficult.

The fine structure of some of the Hα filaments, especially of those well developed, consists not only of normal fibrils but also of quite long thin filaments, twice and/or three times as long as the average length of fibrils. These filaments may be formed by the reconnection of two or more fibrils tightly packed in an Hα filament. One possibility is schematically explored in Figure 6.

While the hypothetical photospheric mass motions of Figure 3 have not yet been observed, such motions at the transition region level have been reported (Athay et al. 1985a,b, 1986a,b). It will be useful to obtain direct photospheric velocity measurements in the vicinity of forming Hα filaments. If such flows are indeed present,

Fig. 4. An Hα filament perhaps formed by anti-parallel motions - see Figure 3a (photo courtesy of Dr. R.B. Dunn and Dr. R.N. Smartt, Sacramento Peak National Solar Observatory).

they may provide a unifying principle behind the diversity of Hα filament structures and formation.

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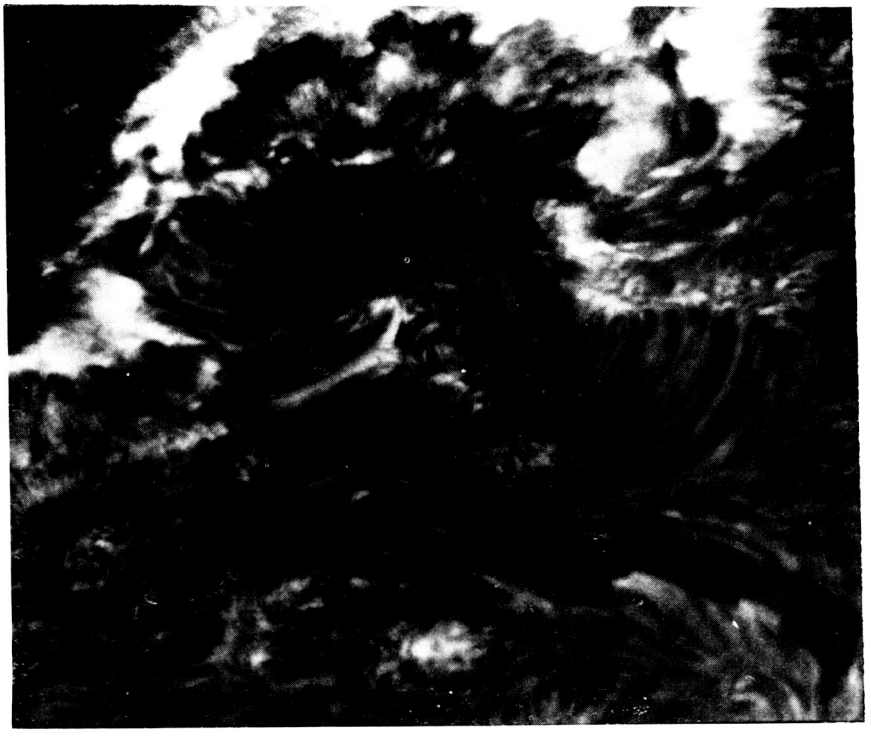

Fig. 5. An Hα filament perhaps formed by parallel motions - see Figure 3b (photo courtesy of Dr. H. Zirin, Big Bear Solar Observatory).

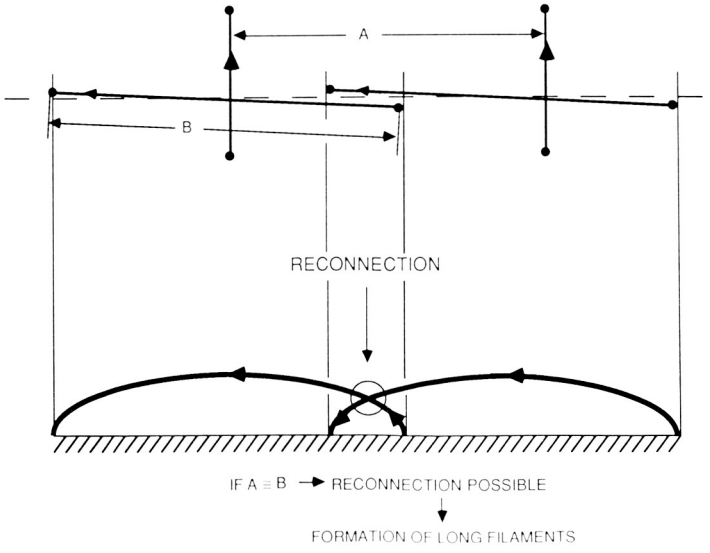

Fig. 6. Scheme for the formation of long, fine filaments in an active region prominence.

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