Hα STRUCTURES AND SMALL-SCALE MAGNETIC FIELD CONFIGURATIONS

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Abstract. Magnetic field observations made utilizing a $\frac{1}{7}$ Å birefringent filter for the Fe I line at 5324 Å resolve magnetic field features comparable in scale to the Hα fine structure. Without exception, low lying filaments in the center of the disk coincide with boundaries of polarity change in the line of sight component of the magnetic field. Small filaments can be identified on a scale comparable to the Hα fibril structures. The arch filament systems are associated with areas of mixed polarity. 'Satellite spots' may sometimes be identified as small localized enhancements of magnetic field of both polarities around the perimeter of a sunspot.

In November 1968, a program of observing solar magnetic fields was initiated at the Lockheed Solar Observatory. The magnetic fields are detected by means of a filter rebuilt by Ramsey (1969) at Lockheed for observing in the Fe I line at 5324 Å. The technique employed is essentially the same as that developed by Leighton (1959) except that in place of the spectroheliograph we employ the $\frac{1}{7}$ Å bandpass Fe I filter in a 17.5 cm aperture refracting telescope. Direct observations in the Fe I (5324 Å) line as in the upper left of Figure 1 show the bright network which is cospatial with the magnetic field network as shown by Chapman and Sheeley (1968) for other photospheric lines. Comparison of the direct Fe I photographs with Hα photographs of comparable resolution, as in Figure 2, shows that the magnetic field network is also precisely cospatial with Hα plage within the resolution of the photographs. The filter magnetograms have not yet been successfully calibrated to yield accurate measures of field strength. However, comparison with Kitt Peak magnetograms of lower resolution ($\sim$2.4 arc s) shows that even weak plage represents field strengths of several hundred gauss, consistent with Chapman and Sheeley's measurements of the field strengths in the photospheric network.

In these high resolution magnetograms it is also confirmed that low altitude filaments relate very accurately to polarity boundaries when observing the line-of-sight fields in the center of the disk. Deviations are generally within the width of the filament. On the basis of this confirming evidence, it seems reasonable to continue defining filaments as absorption features corresponding to lines or zones of 0 line of sight field. Using this definition, it is clear that filaments have a complete spectrum of sizes from those that exceed the dimensions of an active region to those having the same dimensions as fibrils. Examples of the very small filaments are seen in the middle of the active region in the lower right picture of Figure 1. The precise way in which the small filaments lie between network of opposite polarity is better illustrated when the subtracted magnetic field photographs are reproduced first as half-tone transparencies, secondly as color transparencies, and then shown superposed with an Hα transparency as is illustrated in Figure 2. The fine pattern of dots is a result of the half-tone copy.

Howard (ed.), Solar Magnetic Fields, 323–328. *All Rights Reserved.*

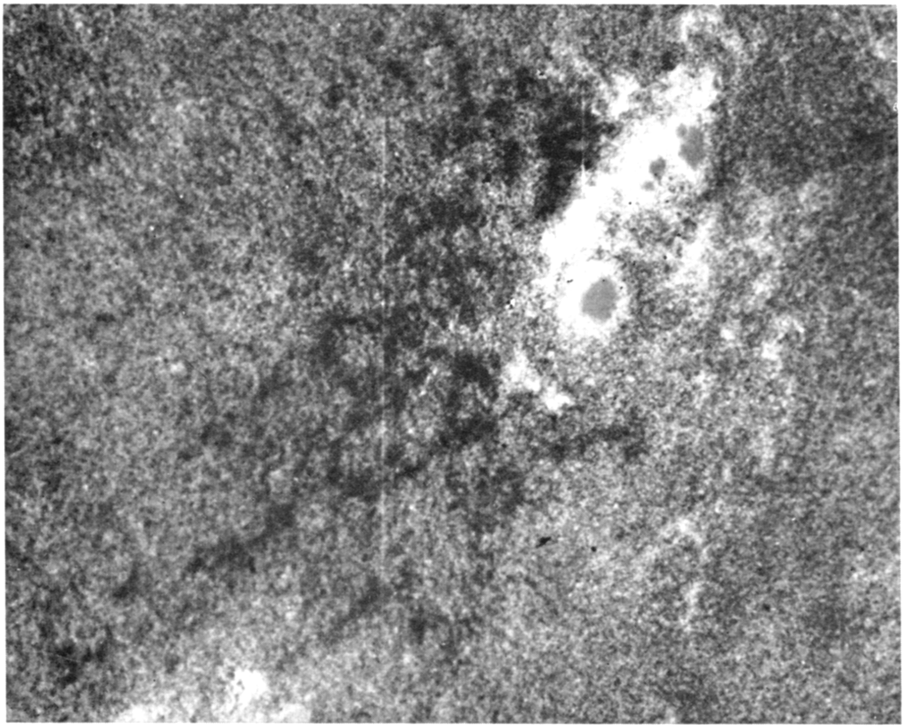

Fig. 1b.

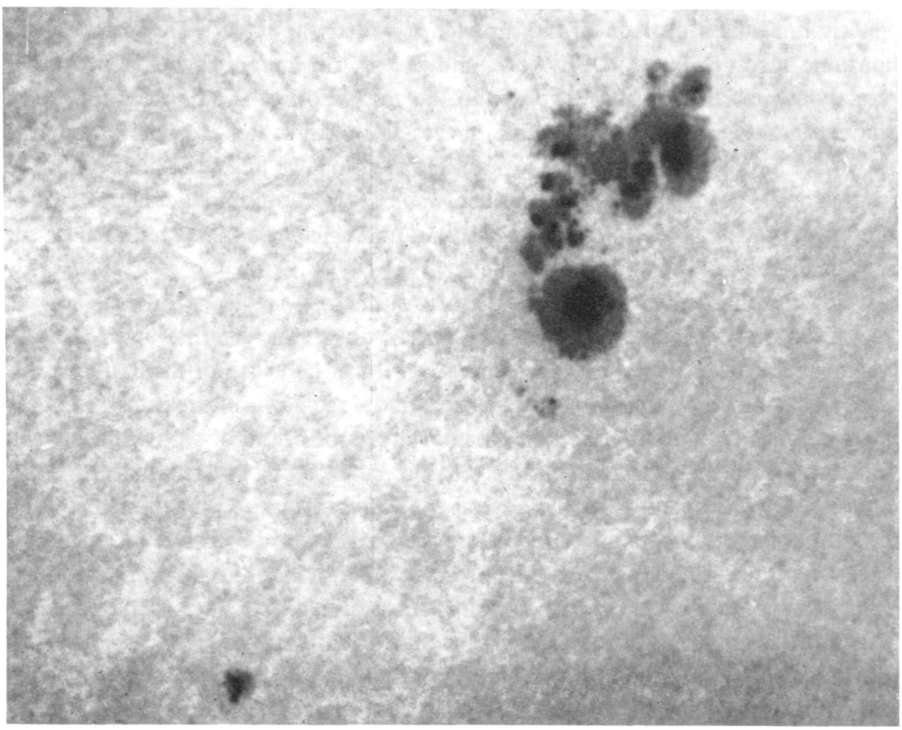

Fig. 1a.

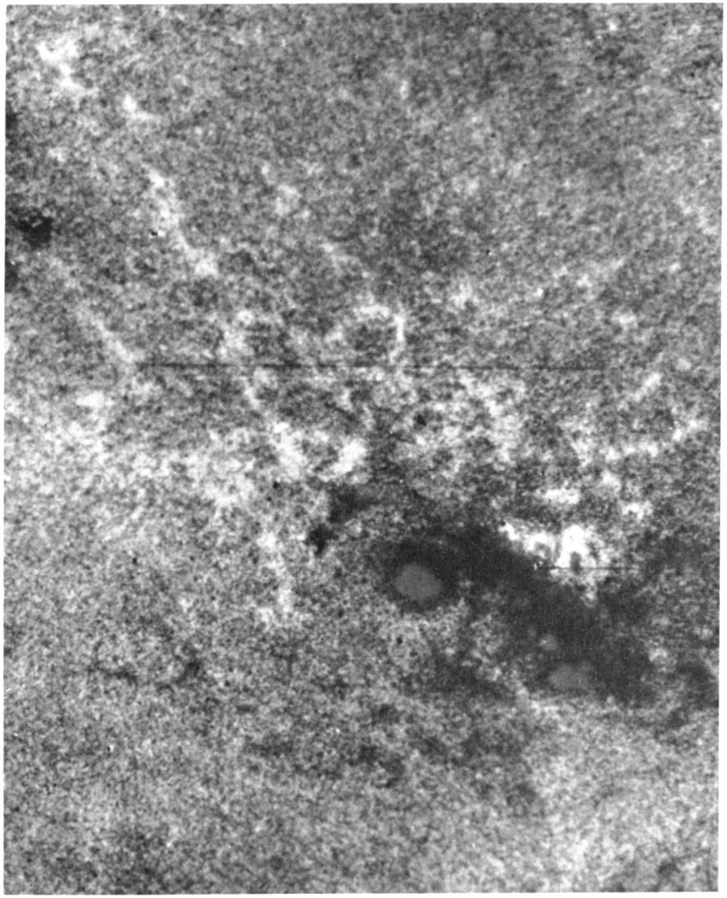

Fig. 1c.

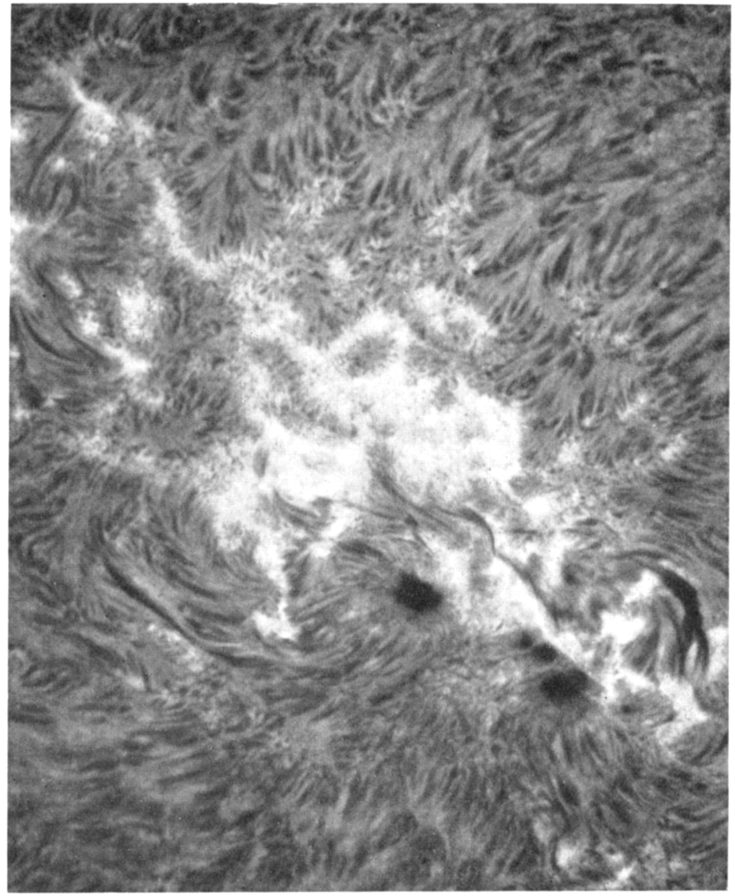

Fig. 1d.

Figs. 1a-d. The bright polarized network in the Fe I line at 5324 Å (a) is cospatial with the Hα plage (d) and with the magnetic field network shown in the photographically subtracted pair of Fe I photographs (b and c).

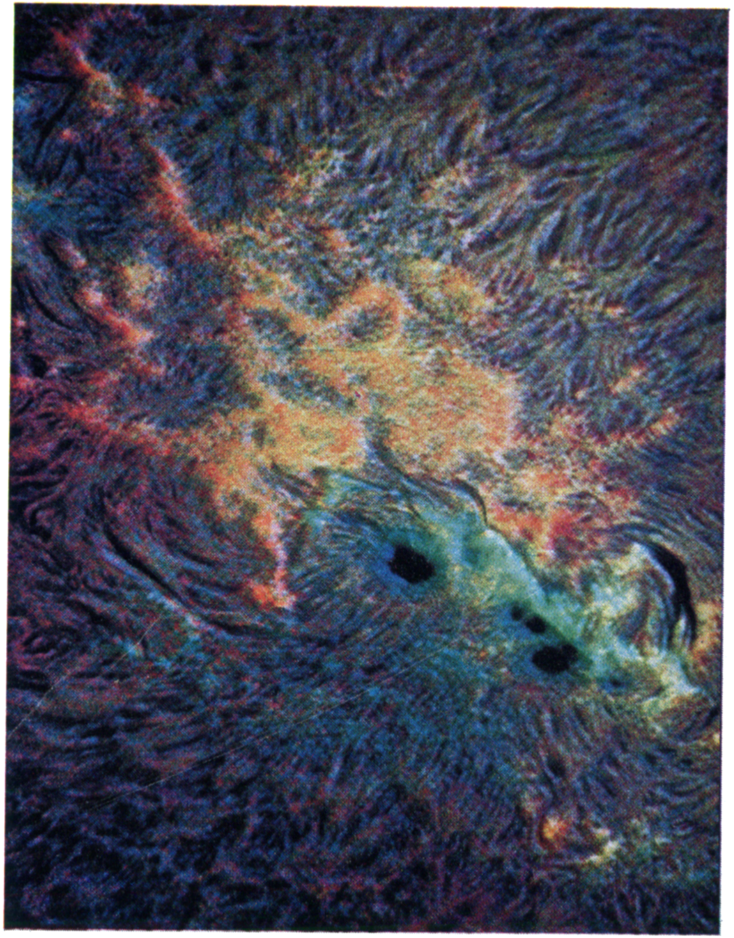

Fig. 2. This illustration is a composite of the magnetic field and Hα photographs in Figure 1. Blue represents positive polarity. Red represents negative polarity. Green represents positive polarity (blue), coincident with bright Hα plage (yellow). Orange represents negative polarity (red) also coincident with bright Hα plage. A system of small filament and fibrils marks the boundary between opposite polarities in Hα.

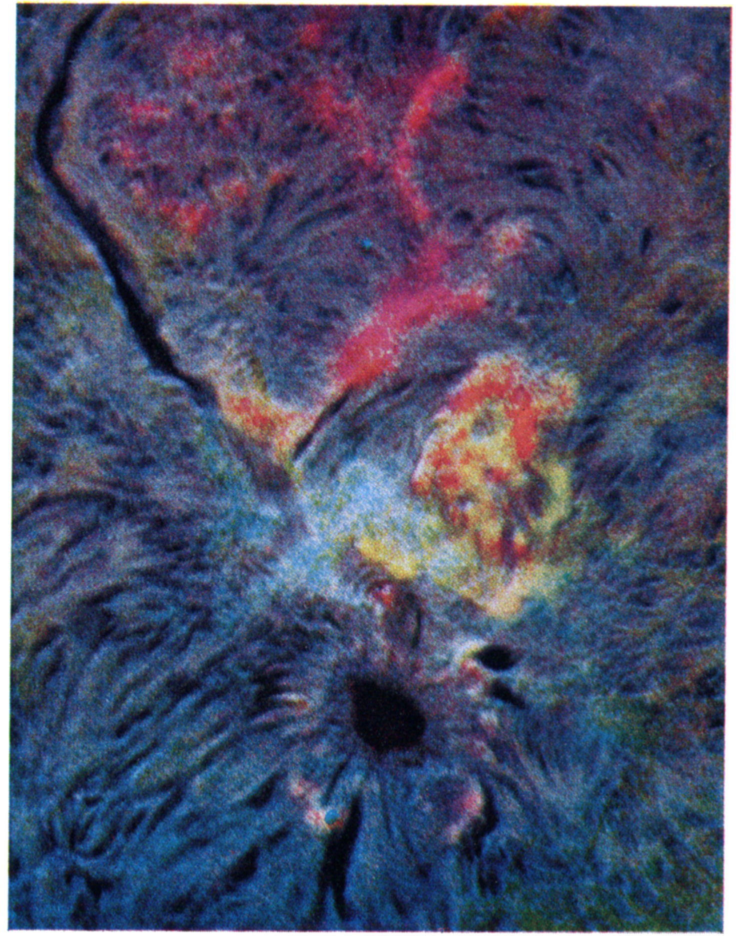

Fig. 3. This composite photograph shows a new active region (mostly orange and green) beginning to develop in an old active region (mostly red and blue). Surrounding the sunspot are small areas of enhanced field of both polarities. Small surges and dark absorption features are related to these 'satellite' poles.

In most respects, the more recent high resolution magnetograms confirm earlier results and provide additional detail about established relationships between the magnetic field configuration and Hα structure. However, earlier results in which arch filament systems are consistently seen as bridges connecting areas of opposite polarity *are not satisfactorily* confirmed in the high resolution magnetograms. Indeed, *sometimes* the fibril patterns, not necessarily identified as 'arch filament systems', do appear as bridges between areas of opposing polarity. However, the relationship of the 'arch filament systems' to the magnetic field configuration as described by Bruzek (1968) seems now to be more complex. There are at least 3 field configurations which can be associated with fibrils patterns or arch filament systems as seen in Hα centerline photographs. First is the classical situation in the upper left corner of Figure 2 in which there is an apparent bridging of opposite polarities. It should be noted however, that frequently, as in this case, these observations differ in some respects from earlier lower resolution observations. The fibril system is only present in the gap of 0 or nearly 0 field between the regions of opposite polarity. The ends of the arches approach but do not overlap the strong magnetic field. The fibrils are not exceptionally dark and therefore not identified as an 'arch filament system'. A second case is near the right border of Figure 2. The dark arches which appear to overlap areas of strong field are separated by weak field. The ends may appear to approach or overlap fields of either the same polarity or opposite polarity. However, considering possible height differences between the observed field and Hα structures, it is not possible to say with any confidence, that the end of a given structure definitively ends in an area of given polarity.

The third case, shown in Figure 3, is a typical arch filament system as described by Bruzek (1968). These are often seen in new active regions; in this case a new active region growing in an old active region. Here, the arches are very prominent due to Doppler shifts (Bruzek, 1968). Instead of a simple bipolar configuration, the fields underlying the arch filament system are a complex mixture of both polarities near both ends of the arch filament system. The scale of the polarity reversals and the arches are comparable making it difficult or impossible to identify an end of an individual fibril with an area of given polarity. In fact, from the improved resolution magnetic field filtergrams, it is questionable as to whether a distinction should be made or can adequately be made between small filaments, various fibrils patterns and arch filaments systems.

Another feature to point out in Figure 3 are the satellite spots described by Rust (1967) which frequently border large sunspots. In the filter magnetograms these so-called satellites may be seen as small compact areas where there may be an enhancement of both polarities instead of just the polarity opposite to the main spot. As noted by Rust small surges may be observed in close proximity to these 'satellites poles'. The base of the surges are thus close to or coincident with the polarity boundary between the two small poles, raising the question of whether or not surges are like filaments in following channels between areas of opposite polarity but in the dimension of the magnetic field we are unable to observe with the filter.

It is evident that many more examples need to be studied before definitive relationships can be established between Hα structure and the fine-scale magnetic field patterns. It is of interest to note, however, that there is a common denominator throughout all of the observations described. The ends of filaments, fibrils, arch filament systems and surges are coincident with or lie within a few seconds of arc of lines or zones of zero line of sight fields.

References

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Leighton, R. B.: 1959, *Astrophys. J.* **130**, 366.

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