EVOLUTION OF STRUCTURES IN THE BRIGHT Hα NETWORK

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Abstract. We present off-band Hα filtergrams showing the bright Hα network (solar filigree) and its evolution, with subarcsecond resolution. In quiet regions the total area covered by elements in the network is constant over periods of hours but changes in the geometry are observed over 10 min (the timescale of granule and dark mottle lifetimes), that can be interpreted as due to (macro)turbulent horizontal velocities of about 1 km s^{-1}. The network can be resolved into strings of tiny bright dots; on the order of 100 per supergranule cell boundary. These dots may mark the location of magnetic filaments. The contrast of the features is higher in the blue than in the red wing which may indicate that in the lower chromosphere, the downdraft at supergranule boundaries does not occur in the bright crinkles themselves but rather adjacent to them.

1. Introduction

The bright photospheric network is cospatial with quiet region magnetic fields, at least when viewed with a resolution of about 2″ or worse (Chapman and Sheeley, 1968a, b; Sheeley and Engvold, 1970). The evolution of this network, as seen in spectroheliograms in the CN bandhead, has been studied by Sheeley (1969).

In off-band Hα photos the bright network can be seen, provided the seeing is good. Its properties when seen under very high resolution were first studied by Dunn and Zirker (1973) and following them we adopt the terminology 'solar filigree' for the bright network and 'crinkle' for the individual elements in the network. At Hα – 1.0 Å a typical width of the crinkles is about 0.5″ and further out from line center, like 2 Å, the widths of the structures are about 0.3″, which makes them very difficult to resolve. At about Hα – 1.0 Å they are coarse enough to be observable with moderate size telescopes, yet retain their identity in quiet regions where adjacent crinkles are typically separated by more than their widths. We are using a 25-cm telescope at Big Bear Solar Observatory with a Zeiss 0.25 Å bandpass filter. Since the structures are separated by distances much larger than their intrinsic widths, the image smearing in the telescope is determined (apart from seeing) by the point spread function (rather than the MTF). For a 25-cm aperture at Hα its full width at half-maximum (50% modulation) is half an arcsecond while the widths at 30% and 20% modulation are 0.4″ and 0.3″, respectively.

2. Observations

A sequence spanning 26 h of evolution is in Figure 1. This is a quiet region well removed from all sunspots and here we can recognize some larger structures from one day to the next; some but not all. The structures in the lower left seem to be quite similar on the 14th and on the 15th, while the complex in the upper part is

R. Grant Athay (ed.), Chromospheric Fine Structure, 257–261.

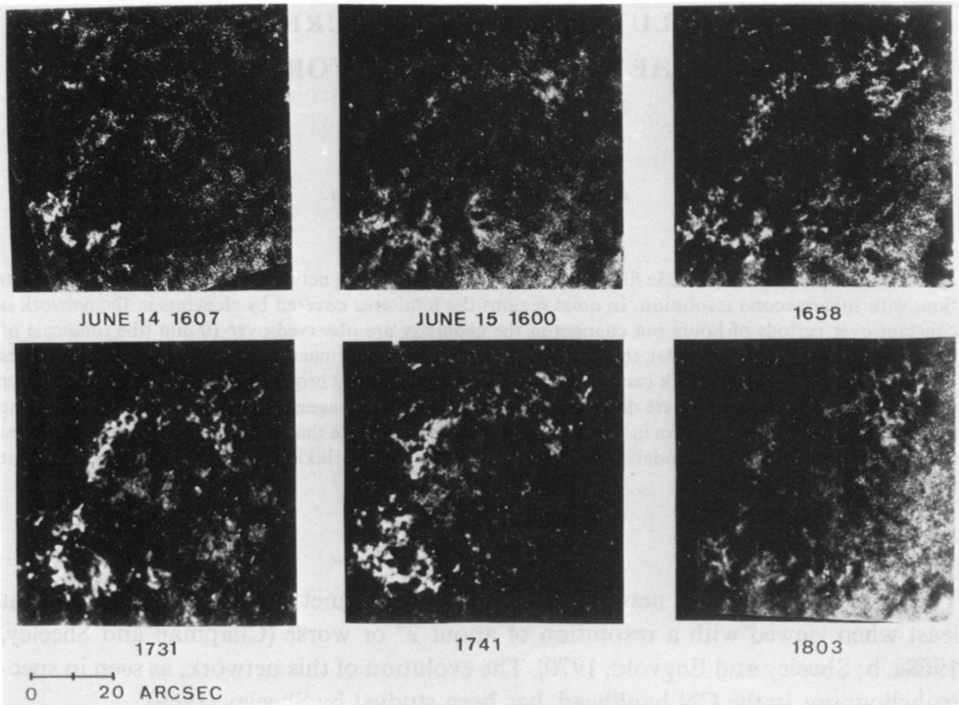

Fig. 1. Evolution in a field June 14–15, 1972. Filtergrams at Hα -1.0 Å (June 14) and Hα -0.9 Å (June 15). Numbers show times in UT. Scale is in arcseconds; $1'' = 735$ km on the Sun. Other classes of features have been suppressed in the printing process.

only visible on the 15th. On the two frames taken during the best seeing (1731 and 1741 UT) we can see numerous changes. Figure 2 shows a small part of the region still better.

It is seen that:

(1) Changes have taken place.

(2) The total area taken up by the bright network has not changed significantly and the bright structures, although changed, still occupy the same regions in the frame.

(3) Some distinct features, like the 1000 km diameter ring-type structure in the lower part, have not changed very much and can be identified on both frames.

(4) There is no coherent flow pattern in the changes.

From this we may conclude that:

(a) For features in the subarcsecond network, changes take place on a timescale shorter, but not much shorter, than 10 min. This is similar to the timescales of granule and dark mottle lifetimes.

(b) That the total area covered by bright crinkles does not change, suggests that the features are the same ones that have been pushed around by some (macro)turbulent flow. An estimate of the average displacement of discrete features between the

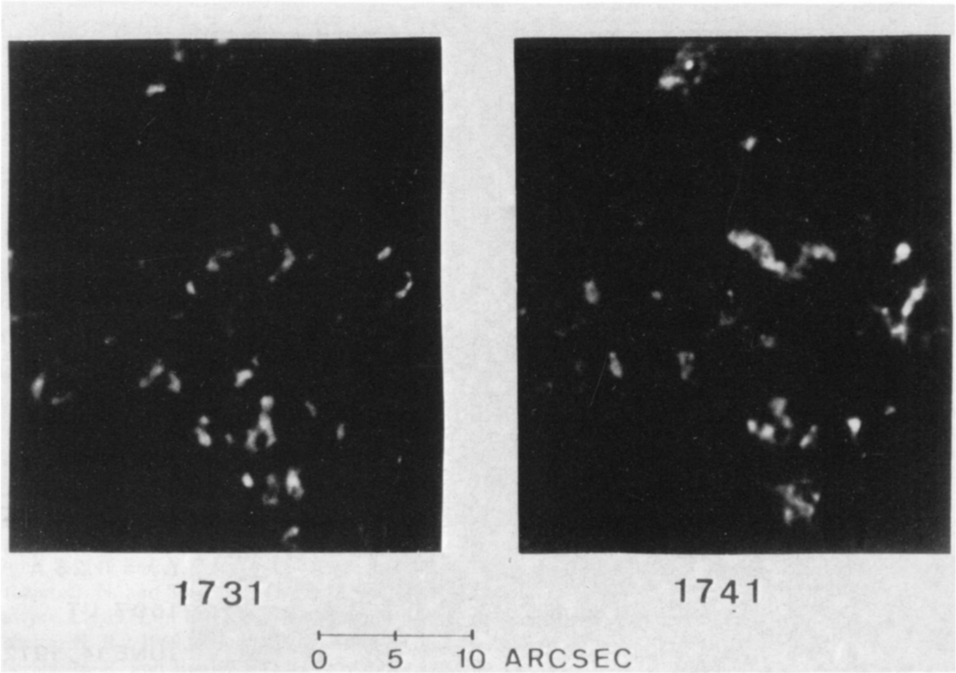

Fig. 2. Evolution in a small field on June 15. Filtergrams at Hα −0.9 Å.

frames in Figure 2 is about 0.8″ = 600 km. Averaged over the time of 10 min this means an average horizontal velocity of about 1 km s^{-1}.

In contrast to this, the enhanced network around a growing sunspot shows a more complex evolution with brightenings and appearence of new features.

The filigree are more prominent in the blue wing than in the red, as can be directly seen by comparing filtergrams taken in different line wings. This, using a naive Doppler interpretation, is contrary to what would be expected if the downdraft at the supergranule boundaries took place in the bright crinkles in the network. One can interpret this as the downdraft taking place immediately adjacent to the crinkles. That dark chromospheric material will be redshifted and the crinkle will be more obscured by the downfalling material in the red wing, making it appearently brighter in the blue wing.

3. Intensity Structure Within Network Elements

In a negative print (Figure 3), the network structures appear dark, i.e. positively exposed, and this makes it easier to study the intensity fine structure within the network. In Figure 3 we see how patchy the bright network is when viewed under high resolution; indeed in many areas it is resolved into strings of discrete dots. The diameters of these dots are below 1″ or so. Along the borders of one supergranule cell we

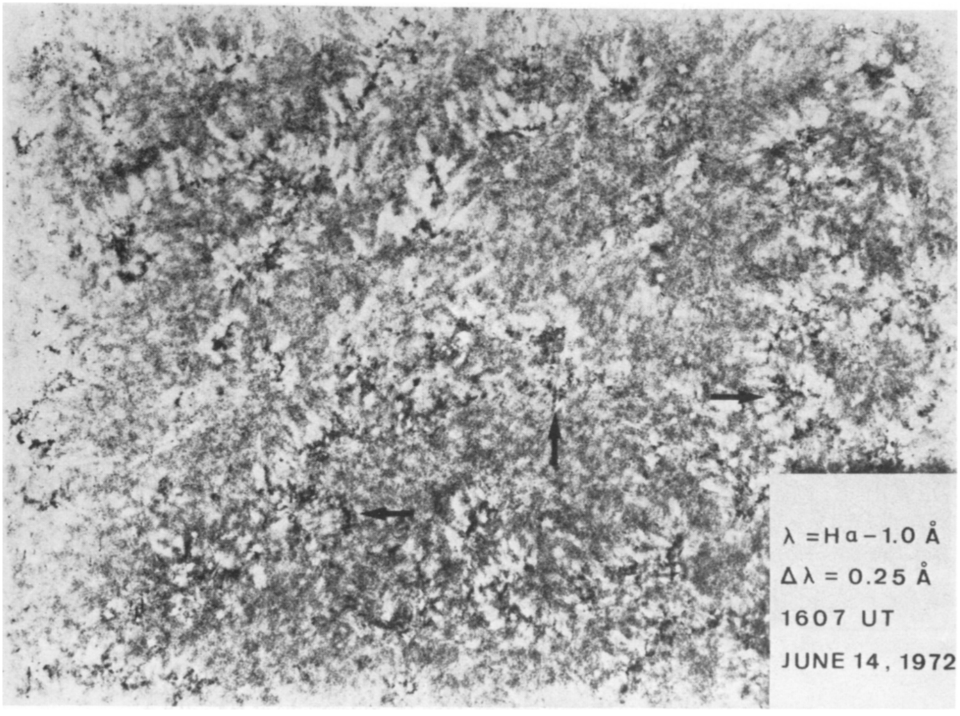

Fig. 3. Negative print of an area surrounding a few very young sunspot pores near center, 1607 UT, 1972, June 14. Filtergram at Hα −1.0 Å, filter bandpass 0.25 Å. Area = 6 × 4.5′. This print shows the intensity structure within the network, much of which can be resolved into dots. The arrows point to some obvious cases.

estimate that there are on the order of 100 such dots. There is no obvious correlation between individual dots and the overlaying dark mottles.

It is tempting to identify the bright areas as locations of strong magnetic fields and an extrapolation to the dots would then identify them as discrete magnetic filaments. From studies of Zeeman-sensitive spectral line profiles, it has been argued that magnetic fields in quiet regions are channeled through narrow filaments of subarcsecond diameter (Frazier and Stenflo, 1972; Stenflo, 1973), which would be consistent with our interpretation. Also Sawyer (1971) observed small size dots on averaged filter magnetograms.

4. Possible Sources of Error

While the seeing as far as image sharpness is concerned, is good in some of our frames, this does not mean that image motion and geometrical distortions necessarily are negligable. Inspection of sequences including the present frames shows that there is an image motion present of some arcsecond also in times of good image sharpness. Does this affect our conclusions? A study of the frames in Figure 2 shows that it would not be possible to obtain one frame from the other by simple geometrical distortion, why we retain our conclusion on significant evolution there over 10 min.

A more difficult factor to estimate the effect of is that of mottle obscuration. If some dark chromospheric material moves into the line of sight to a bright element, that will be obscured and some previously obscured element may be displayed.

Acknowledgements

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DISCUSSION

Pecker: I think one should be very careful in assigning a velocity in the downward direction to a blue shift. It is by no means obvious.

Dravins: Yes, of course, it is difficult to infer such velocities, but I should point out that we observed far out in the line wings and are spatially resolving the features.

Bhavilai: I would like to know whether these small features have been observed in the line center for Hα.

Dravins: I haven't observed them.

Bhavilai: My impression is that the bright mottles at line center overlie the filigree.

Dravins: Yes these are bright regions in the line center. The filigree structure (with the resolution I have been using) becomes visible at about 0.7 Å from line center.